TIN.

TIN.

PRESENT POSITION AS AN INDUSTRY.

Tin mining in the United States presents the exceptional condition of an industry giving employment to many persons, but which at the end of the census year had not reached the stage of producing commercial tin. Although the industry has been in this position since 1884, there seems to be no doubt that tin will eventually be produced. The open question which requires actual production to decide is, whether the industry will be profitable and therefore permanent. This question has excited great discussion, for the reason that tin is produced in comparatively few localities, and hence the usual ignorance of its comparatively humble economic position among the metals.

4 states are at present concerned with enterprises for producing tin, as follows: California, South Dakota, Virginia, and Wyoming. The following table shows the amount of work done in each state in this direction:

TIN STATISTICS FOR THE YEAR 1889. (*a*)

STATES.	Total output of tin-bearing rock. (Short tons.)	Total capital.	Total amount paid for wages.	Other expenditures.
California	5,000	$650,000	$18,464	$12,065
South Dakota	22,000	200,000	181,783	48,752
Virginia	1,000	48,000	1,800	....

a No work done in Wyoming in the census year.

EMPLOYÉS ABOUT TIN MINES IN 1889.

STATES.	Number of openings.	ABOVE GROUND.						BELOW GROUND.					
		Foremen.		Mechanics.		Laborers.		Foremen.		Miners.		Laborers.	
		Number.	Average wages.	Number.	Average wages.	Number.	Average wages.	Number.	Average wages.	Number.	Average wages.	Number.	Average wages.
California	6	2	$4.66	34	$3.30	31	$2.80	1	$6.46	9	$2.81	2	$2.14
South Dakota	621	8	4.39	28	3.25	49	2.50	5	3.60	132	3.00	8	2.50
Virginia	40	1	4.17	1	1.25	11	1.00	....	....	....	....	....	....
Wyoming (*a*)	11	....	....	....	....	....	....	....	....	....	....	....	....

a No work done in Wyoming in the census year.

This table shows that much substantial development work has been done on these various deposits. In all 6,000 feet of shafts and tunnels have been put in, besides 2,500 feet of open cuts. In the above statement of labor and wages no account is taken for the so-called assessment work done prior to patenting the claims, as this does not afford a very definite employment, except to the few contractors for such work.

With regard to the present facilities for producing tin, it should be said that concentrating works are ready for operations at Glendale, South Dakota, and others have been ordered to be built at Hill City. At the Cash mine, in Virginia, a concentrator is to be built, and at the Temescal mines, in California, a small plant is in actual operation. There is a concentrator at the Etta mine, and the Tin Mountain Mining Company has a Cyclone pulverizer and other mining property.

OCCURRENCES OF TIN ORE.

Tin in the form of its oxide, cassiterite, occurs disseminated very generally in granitic rocks. Hence traces of it have been noticed in many places in the United States, and it is very probable that it will be observed in many more localities. It occurs, however, very sparingly. It has been noticed in Maine, New Hampshire, Massachusetts, Connecticut, Virginia, North Carolina, Alabama, Texas, South Dakota, Wyoming, Montana, Idaho, Colorado, and California, and Professor W. P. Blake reports that chemists have found traces of it in the magnetic iron ores of the highlands of New Jersey and New York. Reports of tin ore from Missouri and from the head of Lake Superior have been made, but not confirmed. In all these places the general mode of occurrence is similar, that is, in coarse crystalline rocks, granite, gneiss, mica-schist, etc. Many interesting minerals are found associated with the tin ore, among them fluorite, wolfram, copper and arsenical pyrites, apatite, spodumene, columbite, etc., to which reference will be made in connection with the several localities. A good description of these localities was given by Professor W. P. Blake in Mineral Resources of the United States, 1883 and 1884, and which has given much aid in the following résumé:

NEW ENGLAND STATES.

MASSACHUSETTS.—Perhaps the earliest mention of tin ore in the United States was made by Professor Edward Hitchcock, who found it at Goshen, Massachusetts, in 1829. He describes it as occurring in a granite bowlder apparently derived from adjacent granite in place. He also found it in Beverly.

NEW HAMPSHIRE.—In 1840, Dr. C. T. Jackson discovered tin ore in place in Eastman's hill, at Jackson, New Hampshire. It occurs in small veins 0.5 inch to 8 inches in width in the widest part. The tin ore, which is, as usual, cassiterite, is associated with copper and arsenical pyrites, fluorite, and phosphate of iron. The veins traverse mica slate and granite, in the vicinity of a trap dike. In the middle a streak of quartz subdivides the vein. No tin has been obtained from either of the localities mentioned above.

MAINE.—A more definite occurrence of cassiterite was noticed in the granite rocks in Maine in 1869, by Dr. C. T. Jackson, in the town of Winslow. It has also been found at Paris, Hebron, Peru, Norway, and Rumford. At Winslow there were at least 12 veins, which, according to Professor C. H. Hitchcock, traverse a very hard and compact siliceous and micaceous schist containing pyrite and near a layer of quartzite. The veins are small, from 0.5 inch to 3 inches in width, but numerous. They are generally interlaminated with the rock, though occasionally cutting across it for a short distance. The vein filling consists of white mica on each wall, then a medial line or mass of fluorite, in which the crystals of cassiterite are irregularly dispersed. Other minerals, such as mispickel and beryl, are found. In 1880, after an examination by Professor Hitchcock, the Maine Tin Mining Company was organized to work these veins. A shaft was sunk to a depth of 100 feet and a crosscut made of 20 feet at the bottom; also 1 at 90 feet from the surface. The veins thus cut appeared to be dipping toward each other; 4 had already merged to 2. A sample of tin from this deposit is on exhibition in the United States National Museum, at Washington.

SOUTHERN STATES.

VIRGINIA.—Stream tin has been found sparingly for many years in the gold-bearing gravels in Virginia, but about 1880 cassiterite was found in place on the eastern edge of Rockbridge county, about 8 miles east of Vesuvius station, on the Shenandoah Valley railroad. It has also been discovered over the county line in Nelson county. Various mining reports have been made on the property and much useful information obtained. It seems that there is an area of 3 by 4 miles of exposed crystalline rocks, in various parts of which veins of tin ore and quartz occur. The principal lode is apparently made up of several parallel veins, all extending in coarse-grained feldspar, mica, and hornblende in the general direction of the rock formations, with various smaller offshoots.

The tin ore is cassiterite, in sheets, strings, and nodular masses through the veins. Sometimes the veins are found an inch wide and very pure; in other places they are more or less replaced by white quartz. The associated minerals are wolframite, mispickel, and beryl. The principal opening has been made on Mount Maria, and is known as the Martha Cash mine. Near this and on an adjacent mountain to the southeast many other openings have been made. Various reports by experts have been made on this property, and as they have been more or less favorable, efforts have frequently been made to develop the deposits. The Virginia Tin Mining and Manufacturing Company was organized in 1884, with Mr. Edgar Whitehead, of Amherst Court House, as president. A shaft or two was sunk, and then litigation delayed the development until 1889, when the Boston Tin Mining Company acquired title from the Cash heirs, and have proceeded more vigorously with development work. A vertical cut of about 100 feet by 150 feet horizontally has been made in the mountain and considerable ore piled up. Hoisting machinery and a Golden Gate concentrator have been received at Vesuvius station, and as soon as a good wagon road is opened to the mine development work will proceed rapidly.

The Nelson county deposits are an extension of those in Rockbridge.

The deposits in the southern part of Amherst county are less known. Lately another deposit has been attracting attention near Berryville, Virginia, but is only in the initial stages of development.

NORTH CAROLINA.—Tin ore was discovered in 1883 in Cleveland county, near Kings mountain. Specimens were exhibited at the mechanics' fair in Boston in 1883. Little is known of the deposit, and only slight efforts have been made at development.

GEORGIA.—Minute quantities of tin ore were found by Professor W. P. Blake in the residues of gold-washing operations in Lumpkin county.

ALABAMA.—Professor C. U. Shepard has found tin ore in Coosa county, and Mr. G. W. Gesner, of New York, has found it in Clay county, near Ashland, at what has been known as the Broad Arrow mine, and some work has been done in developing the property, not, however, within the census year. The formation is described by Mr. Gesner as gneiss, through which the tin ore is disseminated in grains and pebble-like masses over a breadth of 10 to 20 feet. It is associated with white quartz and limonite.

TEXAS.—Professor Theodore B. Comstock, with Professor E. T. Dumble, state geologist of Texas, has lately discovered cassiterite occurring in Llano and Mason counties. Professor Comstock states that as yet no workable deposits have been found, but the indications are such as to encourage prospecting. The cassiterite has all been found in a belt of the lowest archæan rocks, trending north 75° west through Llano and Mason counties, with a short extension eastward across the Colorado river into Burnet county. Very much of the material which has been reported as tin ore from this district is keilhauite, tourmaline, or black garnet, but the cassiterite has been collected by members of the survey from 4 localities besides the one in which an old furnace was discovered with tin globules in the slag dump.

SOUTH DAKOTA.—The fact that tin ore exists in the Black Hills of South Dakota has been known since 1877, when it was definitely established by Mr. R. H. Pierce, of Argo, Colorado. Mr. Pierce found grains of tin stone in some auriferous sand sent him by a prospector. No attention was paid to the discovery until June, 1883, when Major A. J. Simmons, of Rapid City, South Dakota, forwarded a box of specimens to General Gashwiler, of San Francisco, which, on examination by Professor W. P. Blake, proved to be cassiterite in a massive form. The mass yielded on examination 40 per cent of metallic tin. A month later Professor Blake examined the property, took an account to capitalists in New York, and published notices of the discovery in the Engineering and Mining Journal and in the American Journal of Science. The Harney Peak Tin Mining, Milling, and Manufacturing Company was formed, and by its example many claims were soon located in the Black Hills.

CONDITIONS OF OCCURRENCE IN THE BLACK HILLS.—The Black Hills have resulted from the upheaval of a mass of archæan rocks in the flat prairie land. The rocks which form the central portion of this uplift are mica schists and slates. In them great lens-shaped masses of granite are found. It is in this granite that tin ore occurs, either disseminated through the rock or in more characteristic vein-like formations. These veins are sometimes coarse mica and quartz and sometimes quartz alone. When contained in a bed of quartz, large pieces of ore are found, but occurring very irregularly. When contained in coarse granite the ore is more finely and generally disseminated. The general shape of the outburst is roughly an ellipse with a north and south axis, and there are a few outlying patches of schists containing tin-bearing granite. The outburst extends from north of Hill City, in Pennington county, down into Custer county. There is an outside upheaval, smaller but of similar character, in Lawrence county, which furnishes the tin mines of the so-called Nigger Hill district, which has been developed over the line in Wyoming. The rock in Harneys Peak itself has so far been found to be barren of tin, but many claims have been opened in the granite around it. The original mine, the Etta, is on the east side of Harneys Peak. Farther to the north several mines have been opened, and the claims become still more numerous in circling the north side of the peak to Hill City, which is perhaps the center of activity at present. To the southwest another group of mines is reached in Custer county, called the Tin Mountain group, and containing the Glendale group before completing the circle to the Etta mine. The Nigger Hill district is just over the boundary line in Wyoming, and here again much prospecting has been done and many mines have been opened.

The following list, while not complete, will give a fair idea of the various claims in the Black Hills:

LIST OF TIN CLAIMS IN THE BLACK HILLS, SOUTH DAKOTA.

CUSTER COUNTY.			CUSTER COUNTY—Continued.		
MINES.	Name of operator.	Post-office address.	MINES.	Name of operator.	Post-office address.
Tin Mountain	Tin Mountain Mining, Milling, and Manufacturing Company.	Chicago, Illinois.	Bird	Charles Harbach	Custer City.
			Covenant	...do	Do.
Cyclone	H. G. Butterfield & Co	Custer City.	Empire	...do	Do.
Crooked S	...do	Do.	Estelline	...do	Do.
Daniel Boone	...do	Do.	Excelsior	...do	Do.
James Wilson	...do	Do.	Florence	...do	Do.
McKinney	...do	Do.	Frankie	...do	Do.
McLaughlin	...do	Do.	Harney King	...do	Do.
Tempest	Dolphin Tin Mining Company	Do.	Henrietta	...do	Do.
Amboy	Gaylord & Russell	Do.	Holiday	...do	Do.
Minnehaha	...do	Do.	Kate	...do	Do.
Oakland	...do	Do.	Link	...do	Do.
Ophir	...do	Do.	Monroe Rose	...do	Do.
Rob Roy	...do	Do.	Pilot	...do	Do.
Alta	Charles Harbach	Do.	Rosetta	...do	Do.
Altoona	...do	Do.	Tin Key	...do	Do.
Alpine	...do	Do.	Duck No. 1	...do	Do.
Belle	...do	Do.	Red Bird	...do	Do.

LIST OF TIN CLAIMS IN THE BLACK HILLS, SOUTH DAKOTA—Continued.

CUSTER COUNTY—Continued.

MINES.	Name of operator.	Post-office address.
Gladstone	Charles Harbach	Custer City.
Louise	E. C. Hunt	Do.
Saint Joseph	Kleeman & Co	Do.
Good Luck	...do	Do.
Halifax	...do	Do.
Saint Joe No. 2	...do	Do.
Saint Joe No. 3	...do	Do.
Tin of Plenty	...do	Do.
Lincoln	C. Lincoln & Co	Do.
Lincoln No. 1	...do	Do.
Lincoln No. 2	...do	Do.
Minnie	McLaughlin & Co	Do.
War Eagle	...do	Do.
Boy	William Olds & Co	Do.
Eldorado	...do	Do.
Great Western	...do	Do.
Saint Joseph	...do	Do.
Saint Joseph No. 2	...do	Do.
Gap	...do	Do.
Great Western	...do	Do.
Clyde	...do	Do.
Jack	...do	Do.
Lily	...do	Do.
Toronto	...do	Do.
Haven	Thomas I. Wheeler	Do.
Saint Luke	...do	Do.
Buckhorn	Clark, Wood & Co	Do.
Idaho	...do	Do.
Wonder Fraction	Medill & Nyswanger	Hermosa.
Wonder	...do	Do.
Jay Gould	Wood & Co	Rapid City.
General Warren	Forydice & Co	Russellville, Indiana.
Wallace	...do	Do.
Woodbine	...do	Do.
Pig Tin	...do	Do.

LAWRENCE COUNTY.

MINES.	Name of operator.	Post-office address.
May Queen No. 2	C. J. Finch	Bear Gulch.
Belle	Finch & Gaston	Do.
Buckeye	...do	Do.
Harrison	...do	Do.
Washington	Hennessey & Co	Do.
Volney	...do	Do.
Giant	...do	Do.
Daisy	Mark Hydliff	Do.
Indiana	...do	Do.
Michigan	...do	Do.
Ohio	...do	Do.
Twin Pine	Jensen & Jackson	Do.
George	Jensen & St. Johns	Do.
Swansea No. 3	McMakin & Co	Do.
Swansea No. 4	...do	Do.
Swansea No. 5	...do	Do.
Dakota	C. Miller	Do.
Homeward Bound No. 1	White & Jensen	Do.
Homeward Bound No. 2	...do	Do.
Ophir	...do	Do.
Alice	James Calanan	Des Moines, Iowa.
Big Blowout	...do	Do.
Charleston	...do	Do.
Crowdog	...do	Do.
Dakota	...do	Do.
Dolcoath	...do	Do.
Diamond	...do	Do.
Jersey No. 1	...do	Do.
Jersey No. 2	...do	Do.
Lulu	...do	Do.
Manchester	...do	Do.
Mary Ann	...do	Do.
Modoc Chief	...do	Do.
New Orleans	...do	Do.

LAWRENCE COUNTY—Continued.

MINES.	Name of operator.	Post-office address.
New York	James Calanan	Des Moines, Iowa.
Poorman	...do	Do.
Pullman	...do	Do.
Spearfish	...do	Do.
Van	...do	Do.
Wanita	...do	Do.
Aurora	...do	Do.
Blackir	...do	Do.
Capleton	...do	Do.
Jay Gould	...do	Do.
Grubb No. 2	...do	Do.
Jackson	...do	Do.
London	...do	Do.
Little Hughey	...do	Do.
Mace	...do	Do.
Surprise	...do	Do.
Star No. 1	...do	Do.
Vanderbilt	...do	Do.
Webfoot	...do	Do.
Yankee Notion	...do	Do.
American Eagle	...do	Do.
Badger	...do	Do.
Blacktail	...do	Do.
Bastinado	...do	Do.
Brooklyn No. 1	...do	Do.
Brooklyn No. 2	...do	Do.
Consolidated	...do	Do.
Custer	...do	Do.
Evening Star	...do	Do.
Green	...do	Do.
January	...do	Do.
Morning Star	...do	Do.
Parnell	...do	Do.
Pink	...do	Do.
Sam Landers	...do	Do.
Silver Wave	...do	Do.
Star No. 2	...do	Do.
Waverly	...do	Do.
West Virginia	...do	Do.
Wrong Horse	...do	Do.
Wyoming	...do	Do.
Young American	...do	Do.
Dakota No. 2	Nigger Hill Tin Company	Lead City.
Dakota No. 3	...do	Do.
Edith	...do	Do.
Nettie	...do	Do.
Sunrise	...do	Do.
Bellfonder	Rhinehart & Co	Do.
Buffalo	...do	Do.
Charley	...do	Do.
Elephant	...do	Do.
Finch	...do	Do.
Miles	...do	Do.
Paid	...do	Do.
Rhinehart	...do	Do.
Rockport	...do	Do.
Total	...do	Do.
Turbine	...do	Do.
Atlantic	American Tin Company	No. 53 Broadway, New York.
American	...do	Do.
Bangor	...do	Do.
Bertha	...do	Do.
Black Eagle	...do	Do.
Boston	...do	Do.
Bear	...do	Do.
Brooklyn	...do	Do.
Chester	...do	Do.
Clara	...do	Do.
Columbus	...do	Do.
Commercial	...do	Do.
Congress	...do	Do.

LIST OF TIN CLAIMS IN THE BLACK HILLS, SOUTH DAKOTA—Continued.

LAWRENCE COUNTY—Continued.

Mines.	Name of operator.	Post-office address.
Connection	American Tin Company	No. 53 Broadway New York.
Cornwall	...do	Do.
Del Norte	...do	Do.
Eureka	...do	Do.
Foxtail	...do	Do.
Grace	...do	Do.
Grand Deposit	...do	Do.
Gray Eagle	...do	Do.
July	...do	Do.
Kingston	...do	Do.
Mona	...do	Do.
New York	...do	Do.
Nigger	...do	Do.
November	...do	Do.
Pacific	...do	Do.
P. D	...do	Do.
Peck	...do	Do.
Portland	...do	Do.
Raddick	...do	Do.
Rattler	...do	Do.
Red Bird	...do	Do.
Robbie	...do	Do.
Rosa	...do	Do.
Ross	...do	Do.
Salva	...do	Do.
Senate	...do	Do.
Soho	...do	Do.
Sonora	...do	Do.
Sontag	...do	Do.
Spur	...do	Do.
Steptoe	...do	Do.
Stratton	...do	Do.
Tin	...do	Do.
Valley View	...do	Do.
Volta	...do	Do.
Walter	...do	Do.
W. J	...do	Do.
Yankee	...do	Do.
Yolo	...do	Do.
Cleveland	Cleveland Tin Company	Do.
Chicago	...do	Do.
Isabelle	...do	Do.
Montana	...do	Do.
Swansea No. 1	...do	Do.
Swansea No. 2	...do	Do.
Uncle Sam	...do	Do.

PENNINGTON COUNTY.

Mines.	Name of operator.	Post-office address.
Peak No. 1	Judge Prindle	Binghamton, New York.
Peak No. 2	...do	Do.
Tin Bell	...do	Do.
Glendale	Glendale Tin Company	Chicago, Illinois.
Hermosa	...do	Do.
Hermosa No. 1	...do	Do.
Ponca	...do	Do.
Ponca No 1	...do	Do.
Dakota Bank	...do	Do.
Garrison	...do	Do.
Hermosa No. 2	...do	Do.
Iron Creek No. 2	...do	Do.
President	...do	Do.
Quincy	...do	Do.
Alabama	Henry Albien & Co	Custer City.
Blue Bird	...do	Do.
Hyena	...do	Do.
Knob	...do	Do.
Occidental	...do	Do.
Old Frank	...do	Do.
Rocky Ridge	...do	Do.

PENNINGTON COUNTY—Continued.

Mines.	Name of operator.	Post-office address.
Dolphin	Dolphin Mining Company	Custer City.
Tempest	...do	Do.
Tornado	...do	Do.
Tin Centre	...do	Do.
Vermont	...do	Do.
Boston	Charles Hamilton	Do.
Clara Belle	Frank Herbert	Do.
Matchless	...do	Do.
Mineral Hill	...do	Do.
Tin City	...do	Do.
Tin Queen	...do	Do.
Black Diamond	Charles Harbach	Do.
Venture	...do	Do.
Lord Thurlow	...do	Do.
Wright	William Olds	Do.
Alta	Caple & Everly	Etta Mine
New York	...do	Do.
Nora	...do	Do.
Albite	Everly & Scott and Lewis Everly & Co.	Do
Brown Tin	...do	Do
Glendale	...do	Do.
Riverton	...do	Do.
No. 6	William Franklin & Co	Do.
No. 9	...do	Do.
No. 10	...do	Do.
No. 11	...do	Do.
Lolo	...do	Do.
Lincoln	Mrs. William Franklin & Co	Do.
Ramelsberg	...do	Do.
Robert T	...do	Do.
Advance	Girard & Co	Do.
Dixie	...do	Do.
Mary Anderson	...do	Do.
No. 1	J. F. Reed	Do.
No. 2	...do	Do.
Tin Bar	...do	Do.
General Sherman	Swanzey & Smith	Do.
Metropolis	...do	Do.
Protector	...do	Do.
Spotted Tail	...do	Do.
Saint Paul	...do	Do.
Chipman	Swanzey & Co	Do.
Hayward	...do	Do.
Jumbo	...do	Do.
Park	...do	Do.
Honduros Fraction	...do	Do.
Honduros	...do	Do.
Little Mohawk	...do	Do.
Union No. 1	Wheelock & Co	Do.
Dauntless No. 1	...do	Do.
Dauntless No. 2	...do	Do.
Dauntless No. 3	...do	Do.
Ideal	...do	Do.
Olive No. 1	Wheelock & Everly	Do.
Olive	...do	Do.
Del Norte	Irwin Allum & Co	Hayward City.
La Belle	...do	Do.
Moltke	August Eagle & Co	Do.
Scotia	...do	Do.
Tin King	...do	Do.
Custer	Henry Huss & Co	Do.
Barney	...do	Do.
Gussie	...do	Do.
Iron Tin	...do	Do.
Moody	...do	Do.
Blair	Robert Ottershanger	Do.
Butler	...do	Do.
Ernest	...do	Do.
Hermosa Fraction	...do	Do.
Miller	...do	Do.
Queen	...do	Do.
Bismarck	Seirth & Co	Do.

LIST OF TIN CLAIMS IN THE BLACK HILLS, SOUTH DAKOTA—Continued.

PENNINGTON COUNTY—Continued.

MINES.	Name of operator.	Post-office address.
Chicago	Seirth & Co	Hayward City.
Cleveland	do	Do.
Sam	do	Do.
Silver	do	Do.
Standby	M. Thomas	Do.
Mountain Lion	Scurlock & Co	Hermosa.
Boone	Allen, Cool & Co	Hill City.
Imogen	do	Do.
Clingstone	Allen & Fish	Do.
Burr	George Burr	Do.
Augusta	Comingham & Co	Do.
Apex	do	Do.
Great Eastern No. 1	Victor Courier	Do.
Mountain Side	Demereau & Co	Do.
Pioneer	do	Do.
Tin Bar	do	Do.
Tin Bullion	do	Do.
Tin Cup	do	Do.
Eclipse	John Good & Co	Do.
Long John	do	Do.
Monte Christo	do	Do.
No. 14	do	Do.
S. & G	do	Do.
Pauline	McBacheron & McCarthy	Do.
Yellow Jacket	do	Do.
5th of July	Joseph McClure	Do.
Tonson	do	Do.
Western Belle	do	Do.
Ida	McCulloch & Co	Do.
Anchor	do	Do.
Dolcoath	do	Do.
Dolcode	do	Do.
Ellen S	do	Do.
Fairview	do	Do.
Ole Bull	do	Do.
Sea Gull	do	Do.
Southern Gem	do	Do.
T	do	Do.
U. P	do	Do.
Buena Vista	Nelson & Co	Do.
Emma No. 1	do	Do.
Emma	do	Do.
Flora May	do	Do.
Good Enough	do	Do.
Good Enough No. 2	do	Do.
Good Enough No. 3	do	Do.
Nettie	do	Do.
Louisa	John Phelan & Co	Do.
Mary	do	Do.
Nellie	do	Do.
Sullivan	do	Do.
May Queen	do	Do.
Buck	Neil Shoemaker	Do.
Buck No. 2	do	Do.
Buck No. 3	do	Do.
Dandy No. 1	do	Do.
Dandy No. 2	do	Do.
Nemo	do	Do.
Oh My	do	Do
Red Star	do	Do.
Sunshine	do	Do.
Tin Queen	do	Do.
Bismarck	Pat. Smith & Co	Do.
Kiote	do	Do.
Surprise	do	Do.
Bullwacker	C. von Wohrman & Co	Do.
Canbready	do	Do.
Eagle Bird	do	Do.
Fly Speck	do	Do.
Gertie Extension	do	Do.
Grand Prize	do	Do.

PENNINGTON COUNTY—Continued.

MINES.	Name of operator.	Post-office address.
Idaho	C. von Wohrman & Co	Hill City.
Snowshoe	do	Do.
Tin Stock	do	Do.
Trojan	do	Do.
Tin Whistle	do	Do.
Wild Dutchman	do	Do.
Yellow Jacket	do	Do.
Standby	W. L. Pike & Co	Longmont.
Monarch	The Peerless Mica and Mining Company.	Madison, Wisconsin.
Monitor	do	Do.
Protector	do	Do.
Newton	L. L. Davis	Rapid City.
Good Luck	Everly & Price	Do.
American	Francis & Co	Do.
Buckeye	do	Do.
Etna	do	Do.
Eureka	do	Do.
Excelsior	do	Do.
Pearl	do	Do.
Portland	do	Do.
Vulture	do	Do.
Yankee Boy	do	Do.
Jack Rabbit	James Haft	Do.
Blue Tin No. 2	Harney City Tin Company	Do.
Blue Tin	do	Do.
Everly	do	Do.
Margaret	do	Do.
Tin Hill	do	Do.
Rose Tin	Jacoby & Everly	Do.
First Find	Samuel Scott	Do.
General Grant	do	Do.
Lulu	do	Do.
Empire City	do	Do.
General Harney	do	Do.
Lucky Boy	do	Do.
Ocean Queen	do	Do.
Brown King	Samuel Scott & Co	Do.
Deacon Wright	do	Do.
Jonathan	do	Do.
Naiad Queen	do	Do.
Gentle Minnie	Scott & Wood	Do.
Grubstake	Sweeney & Co	Do.
Ole Bull	do	Do.
White Elephant	do	Do.
Calhoun	J. B. Taylor & Co	Do.
Darwin	do	Do.
Haines	do	Do.
Jackson	do	Do.
Little Joker	do	Do.
Bell Boy	Taylor & McClure	Do.
Choctaw	do	Do.
Custer	do	Do.
Geitaw	do	Do.
Lilly	do	Do.
Lilly No. 1	do	Do.
Lilly No. 2	do	Do.
Top Sheaf	do	Do.
Wilson	T. Wilson	Saint Paul, Minnesota.
Wilson Lode	do	Do.
Jolly No. 2	Stephens Tin Company	Scranton, Pennsylvania.
Jolly No. 3	do	Do.
Snowbird	do	Do.
Bird	do	Do.
Crow	do	Do.
Eddy No. 1	do	Do.
Eddy No. 2	do	Do.
Jolly No. 1	do	Do.
Little Giant	do	Do.
Peacock	do	Do.
Sunrise	do	Do.

LIST OF LODES OWNED BY THE HARNEY PEAK TIN MINING, MILLING, AND MANUFACTURING COMPANY IN SOUTH DAKOTA.

Addie.
Ajax.
Arab.
Badger.
Ben Butler.
Ben Skinner.
Birdie.
Bismarck.
Black Bird.
Blowout.
Bob Griffith.
Bob Ingersoll.
Broken Link.
Broken Link No. 1.
Broken Link No. 2.
Brown King.
Buckeye.
Butterfly.
Campaign No. 1.
Campaign No. 2.
Campaign No. 3.
Campaign No. 4.
Campaign No. 5.
Cassiterite.
Champion.
Coates No. 1.
Coates No. 2.
Coates No. 3.
Coates No. 4.
Coates No. 5.
Colossal.
Consort.
Cooper.
Cow Boy.
Cow Boy Fraction.
Cow Boy No. 1.
Crow.
Custer.
Czar.
Czar No. 1.
Dapple Grey.
Darwin.
Deacon Wright.
Delaware.
Delia.
Dolphin.
Doubtful.
Duplex.
Edna.
E. Fish.
Elgin.
Endless Chain.
Etta.
Evaline.
Excelsior.
Extension.
Ferguson.
Fifth of July
Florida.
Galena.
Georgia.
Gertie.
Great Eastern.
Greeley.
Grizzly.
Gulch.
G. W. Coates.
Hazelnut.
Helen M.
Hepburn.
Hidden Treasure.
Highland.
Highland No. 1.
Highland No. 2.
Highland No. 3.
Hilda.
Hilda No. 2.
Hortense.
Ida.
Idaho Fraction.
Iron Rod.
Jay Bird.
Jennie.
Jim Fisk.
Julia E.
Junction.
Keystone.
Kit Carson.
Last Chance.
Legal Tender.
Le Grand.
Lizzie.
London.
Madison.
Maggie.
Magnolia.
Mattine.
Merrimac.
Mewonitoc.
Missing Link.
Mohawk.
Moores.
Mugwump.
Naiad Queen.
Nellie.
Never Sweat.
Newton.
No Name No. 1.
No Name No. 2.
Norfolk.
Nutmeg.
Ohio.
Old Jeff.
Peanut.
Pelican.
Pine City.
Ramshorn.
Rover.
Rumby.
Runyon.
Sam.
San Jacinto.
Sarah.
Shorty No. 1.
Shorty No. 2.
Spaniard.
Stannum.
Susan S.
Telegraph No. 1.
Telegraph No. 2.
Tempest.
Thompson.
Tidal Wave.
Tinker.
Tin King.
Tin King No. 1.
Tin King No. 2.
Tin Reef.
Tornado.
Tradesmens.
Transfer.
True Centre.
True Centre No. 2.
True Centre No. 3.
Venus.
Vermont.
Waterbury.
Western Belle No. 1.
Western Belle No. 2.
What Is It.
White Eagle.
White Whale No. 1.
White Whale No. 2.
Wide World.
Wilson.

PERCENTAGE OF TIN.—Although much work has been done in the Black Hills and countless assays have been made, the tin occurs irregularly and the veins are so changeable that very little is known as to what can be expected when the mines are worked. The best evidence which exists is the record of a trial of 40 tons of rock assayed in England; but this is only a fairly large sample which may be better or worse than the average for commercial operations, in which careful selection of the ore would be made. There is little doubt that the test was perfectly fair as far as it went. The prospective English investors in the property sent Mr. M. C. Vincent to the mines, and in connection with his report he shipped to England about 40 tons of rock from the following group of mines: Addie, Campaign, Coates, Cowboy, Custer, Czar, Darwin, Etta, Excelsior, Gertie, Mewonitoc, Missing Link, Mohawk, Sarah, and Tin Reef. From this, 10 tons were taken and crushed by Messrs. Johnson & Mathey, of Hatton Garden, London. From the crushed ore samples were taken by Mr. Frederic Claudet, assayer of the Bank of England, and Mr. Stephen Davis, of Dolcoath, representing the newspaper critics, and a third sample was drawn by Messrs. Johnson, Mathey & Co. The assays were quite uniform and showed that 10 tons would yield from 2.80 to 2.94 per cent of metallic tin of good quality. By ordinary concentrating methods, such as would be adopted in mill practice, 2.60 per cent of metallic tin was obtained.

In January, 1886, Judge Daniel McLaughlin shipped to London 13,000 pounds of ore from the dumps of Mr. James Callanan in the Nigger Hill or Bear Gulch district. In London this was separated into a number of lots and assayed by several dealers. Messrs. Thomas Bolitho & Sons, of Penzance, found 4.6 per cent of metallic tin, Messrs. R. R. Michel & Co. found about the same, and Messrs. Johnson, Mathey & Co. found in a similar specimen 3.6 per cent of metallic tin.

DEVELOPMENT WORK.—The discovery by Major Simmons that the Etta mine, which he worked for mica, contained tin ore led to its examination by Professor W. P. Blake and the formation of a company in New York to develop it. This was carried out in 1884 on quite an extensive scale under the management of Mr. Gilbert E. Bailey, who had previously been territorial geologist. A mill was erected for concentrating the ore, and in 1885 a trial run of 400 tons of ore was made with the following results: black tin concentrates were obtained which yielded 7 tons of metallic tin, and Professor Frank G. Carpenter found appreciable amounts of cassiterite in the tailings, or waste from the mill. After this the mill and the development of the mine were abruptly stopped, and the attention of the company turned to bonding and purchasing the many prospects found in all directions. The mill run attracted wide attention. Most extravagant statements were made as to the richness of the tin ores to be found, and these, as is usually the case, called forth equally wild and untrustworthy denunciations against the entire tin resources of the Black Hills. It has been asserted by most reputable mining engineers that the mines usually contained nothing but worthless columbite, and that in no case would mining pay if the tin were as valuable as silver. But nevertheless the search for tin prospects has gone on energetically from 1884 to the present, the principal impetus being the comparative ease with which a customer could be found in the Harney Peak Company. This, however, was not the only enterprise which has gone further than prospecting. In the neighborhood of the Custer group of mines the Tin Mountain Mining Company has erected a concentrator with a Cyclone pulverizer in the hope that this might prove more efficient in dealing with the micaceous gangue. This plant is still in readiness for work, but nothing was done with it in the census year. In the Glendale region, already referred to, a very complete concentrating plant stands nearly finished. It is connected with the mines by an efficient system of wire-rope conveyors. In the Nigger Hill district the Cleveland Tin Mining Company has made an independent effort to the extent of putting the mines in condition for shipping, and is waiting for reduction works. The same is true of the Stevens Tin Mining Company. At present the attitude of all these independent concerns seems to be that of waiting for further developments by the pioneer company, when purchasers can be found or custom concentrators and reduction works can easily be obtained. Attention is entirely directed to the development work of the Harney Peak Tin Mining, Milling, and Manufacturing Company. In 1888 this company extended its nominal capital of $10,000,000 to $15,000,000. This was done in London after first withdrawing the enterprise on account of energetic attacks by some English papers. After the visit of English mining men to the mines, however, the capitalization was extended. This very great and, as in many such mining enterprises, entirely presumptive valuation was made upon the data already given, showing by fair tests that 40 tons of ore had been collected from various groups of mines, yielding 2.94 per cent of metallic tin. From that time to the present prospecting and development of the more promising openings have gone on. Hoisting plants have been erected at many openings, and underground developments have proceeded as indicated in the statistics already given. In 1889 attention was given to the selection of a site for a concentrating plant. The care in this selection of a site and in the method of treating the ores was manifestly necessary since the conditions include producing tin with very great cost for labor compared with all competitors, and the lesson of the Etta mill shows that ore can easily be lost in the tailings. The developments should go forward with much greater rapidity hereafter because the Burlington and Missouri River railroad has been opened through Custer and Hill City to Deadwood, and the introduction of heavy machinery is no longer so expensive. In July, 1891, Hill City was selected as the site for the concentrator. The contract for its erection was at once given, and the work has been commenced.

CALIFORNIA.—Deposits of tin ore have long been known in San Bernardino county, about 60 miles east of Los Angeles. The region is commonly referred to by various names, as Temescal, from the mountains on the northeast and the creek on the southeast, or as San Jacinto, the name of the ranch in Mexican times on which the deposits occur, and as Cajalco, the name of the principal opening. The tin lodes are found in a formation of granite, extending for several miles northwest and southeast. A dark-colored porphyry rises 700 feet on the east of Temescal creek. After crossing about 2 miles of this it changes in color to gray, and then the granite is reached, which gives place to light-colored porphyry about 5 miles farther east. In this granite a succession of lodes of all widths up to 12 feet are met, generally at right angles with the trend of the granite and dipping to the northwest 60° from the horizontal. More than 60 of these veins have been located and their courses determined. These veins or lodes are made up of quartz, chlorite, oxide of iron, and cassiterite. The oxide of iron gives a peculiar appearance to the tin ore different from that found elsewhere. The property is still in the form of the San Jacinto estate, an irregular tract of about 15 square miles, about 3 miles wide by 5, in the direction of the granite strip. The town of South Riverside adjoins it on the north. In 1846 this property was received as a grant by some Mexicans from the Mexican government. Many years afterward it became the field of a considerable gold-mining excitement, and this prospecting developed the tin lodes. After this the San Jacinto Tin Company bought the titles of the Mexican grantees and have been perfecting the titles since then.

The Supreme Court of the United States has finally confirmed their title, and, litigation ended, the property came on the market for extension of capital and the proper exploitation of the lodes. So far, this consists principally in the work done on the Cajalco lode, which showed heavy outcroppings of tin ore. An adit was run in for a short distance on the lode on the south side of a small ravine at a level about 70 feet from the highest outcroppings. On the north side of the ravine the adit has been run in over 400 feet and an incline shaft sunk on the vein intersecting and ventilating the adit tunnel. The shaft also connects with a lower level under the main adit. The tunnel shows 6 feet of tin-bearing ore in many places. There are in addition many prospect holes and ditches on the other claims. It is proposed to develop the lodes by a long adit tunnel to the creek, where concentrating and reduction works are to be located.

In 1890, by the vigorous work of Mr. E. N. Robinson and others, the concentrating of the tin ore was begun, and up to May 23, 1891, about 12 tons of pig tin had been reduced. A telegram from the company on that date stated that they were producing 1,000 pounds of pig tin daily with a 5-stamp mill, and expected to increase this plant to 60 stamps in 90 days.

All the analyses which have been published show a very favorable percentage of tin in the rock, although the working assays from the recent mining have not yet become accessible; but the increased activity at the mine in 1891, with more than 100 employés, shows the owners' confidence in the enterprise.

FOREIGN PRODUCTION OF TIN.

WORLD'S SUPPLY.—The amount of tin demanded for the world's consumption is annually about 53,000 short tons, about one-sixth as much as the copper or one-eighth of the zinc or one-tenth of the lead consumption of the world. Many countries have contributed to this supply, among them the Straits Settlements of Malacca, including the islands of Banca and Billiton, Queensland, New South Wales, Victoria, Tasmania, India, Burmah, Japan, China, Cornwall in England, France, Germany, Austria, Italy, Spain, Portugal, Russia, Sweden, and South America. Cassiterite has been found in several other localities, especially in Durango, New Mexico, and at Wicklow, Ireland. The present supply, however, comes from the Straits Settlements, Banca and Billiton, Australia, and Cornwall, as shown below:

WORLD'S SUPPLY OF TIN FOR 10 YEARS.

[Tons.]

ITEMS.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.
Total	38, 321	39, 403	39, 671	45, 746	44, 252	43, 699	45, 557	50, 371	50, 721	52, 978
English production	8, 918	8, 615	9, 300	9, 307	9, 574	9, 331	9, 312	9, 282	9, 241	8, 912
Straits shipments to Europe and America	11, 735	11, 400	11, 705	16, 958	17, 548	17, 320	19, 674	23, 977	23, 855	28, 295
Australian shipments to Europe and America.	9, 177	10, 100	10, 067	11, 121	9, 337	9, 088	8, 064	7. 750	7, 975	6, 800
Banca sales in Holland	3, 756	4, 548	4. 399	4, 203	4, 193	4. 200	4, 379	4, 384	4. 439	4. 114
Billiton sales in Java	4, 735	4, 740	4, 200	4, 157	3, 600	3, 760	4. 128	4, 978	5. 220	4, 857

The greatest producing region at present is in the British Straits Settlements, on the Malayan peninsula. The axis of this peninsula is a granite ridge averaging about 3,000 feet in height, which seems to contain cassiterite generally distributed through it. Although the rivers are very short, great alluvial deposits rich in tin ore have been formed from the disintegration of this granite. These alluvial deposits are the chief source of the tin at present, and the great yield, aggregating half the product of the world, is due to the cheap mining possible in such placer beds. The same conditions hold in the adjoining Dutch East Indies, where the islands of Banca and Billiton furnish over 10,000 tons each year.

The literature concerning the mode of occurrence of tin, the mining methods, rates of wages, etc., in the East Indies is very scanty and makes particularly valuable the excellent description of the alluvial tin deposits of Siak, Sumatra, which Mr. Charles W. Rolker, E. M., has lately published in the Transactions of the American Institute of Mining Engineers, and which is condensed below:

Tin was discovered in Banca as early as 1710, and has been produced there ever since; but the supply has been most important since Banca came fully into the possession of Holland, in 1821. In Billiton and the adjoining island of Sing Rep, the existence of tin was known prior to 1822. (*a*) The Lingganese knew of its existence in the valley of Embalong, from creeks and streams in the neighborhood of Tima and Simper hills, on Billiton and also on Sing Rep island, but the prevailing superstition that tin mining brought misfortune influenced them to let this industry lie idle. The attempts of the Dutch government to test this question were lukewarm, perhaps by reason of the fear of reducing, through new discoveries, the price of Banca tin, and the island was abandoned in 1826, leaving only a military post. In 1850, Dr. Crookewit, a chemist and naturalist, was sent out to verify the rumors that tin existed in Billiton. His report was unfavorable; but in 1851 Mr. C. De Groot, a mining engineer, found tin readily, and the active work on Billiton dates from that time. Less than 500 tons were produced during the first 10 years, and 3,000 tons in the next decade. Billiton tin mining is done by private parties, while 70 per cent of the mines of Banca are controlled by the Dutch government. Formerly that government controlled all the Banca mines. The Banca metal is shipped to the island of Java and exported from the port of Batavia to Holland. It figures in the markets as tin exported from Batavia.

In the Malay peninsula the Chinese are known to have worked tin diggings as early as 1793. Since then the development has been gradual until a comparatively recent date. In 1866 the exports of tin metal (white metal) amounted to 5,692 tons; in 1874 the total was 13,566 tons; in 1883 it was 17,195, and rose to 28,492 tons in 1889, an increase of 65 per cent. This shows the extensive development of tin mining in these parts of the world. The energy displayed is great in view of the natural conditions of the country and the disadvantages under which work is prosecuted.

New tin fields will unquestionably be found in the peninsula, as well as within that belt of countries or islands which lies between Australia on the south and the Malay peninsula on the north, known as the Sunda, and their adjacent islands, but so far no considerable production can be traced from any of the latter districts outside of Banca and Billiton. Prospecting and developing the islands referred to will be slow and difficult, because of their dense tropical vegetation, unfavorable climate for labor, and a lack of facilities for such enterprises.

The tin deposits of Banca and Billiton, the types of the Indian archipelago, are mainly alluvial, although some lodes, supposed to be of recent origin, have been worked. According to Davies, the bed rock of the country is granite, metamorphosed slates, quartzites, and sandstones. A cross section through the Banca deposits would show, following from bed rock upward, an average of 3 feet of tin ore overlaid with coarse sand, followed by clay (red, white, and black), then coarse sand, with pockets of clay and layers of fine sand carrying a little tin ore, and then humus. The average overburden is 25 to 35 feet thick. Similar conditions are said to exist on the Sing Rep, Carimon, and other islands, where so far only desultory prospecting has been done, without financial success, or where companies have only lately been organized for work. Tin has been found as far east as the island of Floris, in the Floris sea. The tin of Banca and Billiton has been traced to its original sources in the granite and gneiss; it is also found cutting through the supposed

a Dr. Th. Pozewitz, Peterman's Geographische Mittheilungen, 1887.

overlying quartz schist, clay slates, and clayey sandstones, but, so far as can be learned, very little lode mining has been profitably done. In the Malay peninsula tin lodes have been found, in addition to alluvial tin, and preparations are in progress to test their value.

The attention of capital was lately directed to a tin field on the island of Sumatra and within the district of Siak. It lies inside a large tract of land, estimated by the promoters to contain 400,000 to 500,000 acres, conceded by the sultan of Siak, Iri Indrapoera, in 1887 to Dutch parties "for the extraction of tin and other minerals which appear in that part of the dominions". The official limits of this concession are quoted to define the geographical position of what is considered the tin belt of East Sumatra. The ground conceded by the sultan is bounded "on the north by the part of an imaginary line running from Loeboehbandahara, on the Rohkan river, as far as Tandjong Maris to the Tapong Kanau river (in Siak), and further by the Tapong Kanau river; on the east by an imaginary straight line drawn from the southern boundary of Siak, straight from south to north, and running through Batoegadja as far as the Tapong Kanau; on the south by the independent states to Kampang Kanau and the Podang highlands, and on the west by the Rohkan states". These are the official boundaries of the tin fields, based on the knowledge of the government. Since all inhabitants working the tin deposits are obliged to pay a tax to the sultan on the tin produced, it is to be assumed that the government had a guide in thus delineating the confines of the prospective tin fields, in addition to its knowledge of the work of an exploring party in 1881.

Sumatra is divided longitudinally, by volcanic ranges, into the east and west coast country. The west coast is a narrow strip of land, 20 to 30 miles wide, underlaid, according to Dutch geologists, with granite; in places it is covered with alluvium and coral formation, sandstones, slates, and volcanic rocks. Marble and coal are found near Podang, and the precious metals are mined in other parts. Several railroads extend from the coast to the foot of the mountains above mentioned. East Sumatra is a generally low and slightly undulating country, of the geology of which little is known. Marshy districts abound in consequence of the extensive flood plains of the large rivers. The rivers rise in the divisional range and flow in a tortuous course to tide water, but as they approach it the big streams grow sluggish and form more or less distinct deltas. The main rivers, taken in order from north to south, are the Rohkan, the Siak, the Kampar, the Indragiri, the Jambi, and the Pelambang. The last is said to be navigable for more than 200 miles for large vessels. Each river system has numerous tributaries.

The climate of east Sumatra is warm and moist. Rains abound from October to March. The remainder of the year, although spoken of as "the dry season", is far from arid. Thus at Kotta Ranah, lying inland in the Siak district, there were from the 15th of June to the 1st of July 3 rainy days, on which the rainfall amounted to 71 millimeters. During July it rained on 17 days, the total rainfall amounting to 289 millimeters; in August rain fell on 21 days, to the amount of 282 millimeters; and during the first 7 days of September rain fell on 6 days, to the amount of 98 millimeters; that is to say, out of a total of 84 days in the height of the "dry season" it rained on 47 days a total of 740 millimeters, or an average of 15.4 millimeters for each rainy day.

On an average it rained nearly every other day at Hilversum in Siak, with an average rainfall of over 18 millimeters per day. This is a better showing than that of Kotta Ranah, further inland, as given above, but the average would be greater if January and February had been recorded.

As a result of rains and the level character of the wide eastern country, flooding of the districts traversed by the main streams and their tributaries is a frequent occurrence, and marshy land abounds. This is especially the case along the Siak river and south of it.

The tin fields of Sumatra are approached by steamers of 12 feet draught running from Singapore across the straits of Malacca to Brewer straits, up the Siak river to Benkalis, thence south to Siak and east to Packanbaroe. The distance up the river to Packanbaroe is, according to the captain of one of the steamers, 120 miles. Beyond Packanbaroe the Siak river becomes very sinuous, is obstructed by fallen trees and logs, and, still further up, grows shallow. In consequence all traveling from Packanbaroe upstream is done in bloncongs, or partially covered canoes of a similar type to that used on some streams of South America (Magdalena river, etc.). The bloncongs are propelled by poling or rowing, as the case may require. From Packanbaroe the Siak winds in an easterly direction to Getti, which lies about 20 miles along the river beyond Batoe Gadja, the place mentioned in the description of the boundary of the concession as the one through which the north and south line runs. There may be counted 176 curves or bends of the stream between Kwalla and Batoe Gadja. Kwalla, at the junction of the Tapong Kanau (right arm) and Tapong Kiri (left arm), forming the Siak river, lies about 20 to 22 miles upstream from Packanbaroe. This gives more than 2 curves for every mile along the river. Many of these bends are rectangular turns, and quite a number of loops and return loops are met, which make navigation impossible for any but small craft. The cost of transportation, part by steamboat, part by canoe, entailing the breaking of bulk, the use of storehouses, etc., is naturally a heavy charge against any enterprise commenced in this district. Whoever is acquainted with tropical streams, subject to floods and incidental dangers from drift timbers, etc., will view the making of this river navigable as a difficult and costly undertaking, especially if it is considered that the waters of the stream (more than 100 feet wide) rose at Batoe Gadja in the "dry season", between July 18 and September 13, 1890, more than 18 feet; yet this was an ordinary season. The substitution of land transportation for the natural water ways would encounter special difficulties, arising from the marshy condition of that part of east Sumatra.

Any enterprise undertaken near the interior of Sumatra is for the present confronted with inherent obstacles and disadvantages, involving heavy initial costs which can be offset only by extraordinary richness of the natural resources to be developed.

The present center of operation in this tin field is Kotta Ranah, lying about 300 feet above the sea, in longitude 100° 43′ east, latitude 0° 26′ north, and connected by a trail, not more than 15 miles long, with the Siak river station Getti. Over this trail all freight is carried on the backs of the native Malays. The trail is bad. Probably one-third of it passes through marshes and swamps, over fallen trees and logs, where leeches, the pest of these regions, abound. The second third passes over low, flat lands, and the remainder over rolling hills. Transportation over this distance cost formerly $1, Mexican money (*a*), per load of 40 pounds; it has now been reduced to 66 cents per load. Bloncong hire from Packanbaroe to Getti for shipment of supplies costs $30 to $35 per bloncong for the round trip, but if steadily employed bloncongs can be rented for $55 (Mexican money) per month. Communication is naturally slow. The average time occupied by a bloncong in a round trip, from the steamer discharge pier in Packanbaroe to Getti and Kotta Ranah and back, is 15 days. Temporary heavy floods or very low water may increase the time required. As much as 22 days has been consumed in the trip. The drawbacks and inaccessibility of this region have been emphasized in order to contrast it with the naturally advantageous situation of Banca, Billiton, and other tin-producing competitors.

Kotta Ranah lies about 6 miles northeast of Bukit Siligi, the 3 high peaks in the most easterly chain of the divisional ranges. The axis of this range runs northwest and southeast, and mountain spurs extend from it to the northeast out into the lowlands. These spurs form local watersheds to the tributaries and subtributaries of the Siak and other rivers. Kotta Ranah is a native hamlet (kampong) situated on the stream (sungi) of Lau. The Sungi Lau unites beyond Kampong Kebon with the Pelambayan, forming the Talanca, a tributary to the Tapong Kiri (the left arm of the Siak river.) It may here be noted that the Malay names the banks of a river as he faces them in going upstream, and calls that the left bank or left arm which in this country would be called the right.

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a The peso, or Mexican dollar, is current in Sumatra and Singapore as the trade-dollar of the country.

The nearest kampong to Kotta Ranah is Rambei, on the Sungi Rambei. It lies about 2 miles in an air line northwest from Kotta Ranah. The two hamlets are separated by the foothills of a narrow side spur, divide, or rib, which forces the Rambei stream northeasterly to its junction with the Getti river. The latter has its confluence with the Tapong Kiri (left arm of Siak river) at or about the settlement of Getti. The Rambei and Lau are two distinct stream systems, but both are subtributaries to the Tapong Kiri. The two systems traverse a considerable area, when it is considered that the streams extend yet for miles beyond Kotta Ranah and Rambei, and that the distance from Kotta Ranah to Batoe Gadja, via Kebon and Pelambayan, is nearly 19 miles by measurement; from Kotta Ranah to Getti, estimated, say, 14 miles, while Getti and Batoe Gadja are probably only 10 to 12 miles apart in a straight line. Any kind of material entering the creeks or bycreeks of these streams is likely to be carried through the territory and eventually into Siak river.

The Lau-Rambei system of streams with its tributary creeks forms the basis for the tin operations of the concession above described. A careful examination of the only natural exposures of rock, namely, those occurring in the water channels, and local tests made by borings and pits, leads to the conclusion that the tract under consideration is everywhere underlaid with impure sandstones and quartzites. The partially decomposed red and yellow sandstones near Kampong Kotta Ranah become reddish-gray, and grow micaceous and siliceous as they are traced in the direction of the headwaters of the Sungi Lau toward Bukit Siligi. In the lowlands of Kotta Ranah the dip is generally very slight to the southeast. As the hills are entered the dip increases, and locally along the upper Lau the sandstones are tilted vertically, though flattening again beyond. This hard, fine-grained, gray cascade sandstone consists, according to microscopic examination, of rolled grains of quartz, with abundant amphibole and biotite, scales of white hydro-mica, particles of kaolinized feldspar and iron ocher. The headwaters of the Sungi Blevon (Rambei district) come, to judge by appearances and their mode of occurrence, from a fine-grained reddish or greenish quartzite.

Near and west of the headwaters of the Sungi Batang (Kotta Ranah district), and for 1,500 to 1,700 feet along its banks in the ravine, bowlders, blocks, and pieces of a black compact quartzite, somewhat resembling the whinstone of Cornwall, were found, indicating its occurrence in situ on the adjacent hill. The two quartzites differ in appearance, but under the microscope they seem to show similar origin and constituents. In fact, the transitions to the siliceous and micaceous standstone, so well marked to the eye, nearly disappear under the microscope. Even the ordinary red, yellow, and yellowish-green impure sandstones show similar constituents, only in differing proportions and varying stages of decomposition. As a check to the microscopic examinations of finely pulverized rock-samples, different characteristic samples were submitted to Dr. A. Julien, of the Columbia School of Mines, for thin section examination. What is termed quartzites Dr. Julien calls "sandstones, quartzitic in hardness and compactness". All the rocks are unquestionably of sedimentary origin. The quartzite of Sungi Blevon is composed of rolled grains of quartz, with an abundance of amphibole, a little biotite, and mennacanite. The quartzite of Sungi Batang has the same constituents, only amphibole occurs in very small proportions, and a small quantity of pyrite is present.

The yellow and red sandstone represents results of decomposition. The more or less rounded grains of quartz, which predominate, are cemented by iron ocher, in association with a fine mixture of decomposed scales of hydro-mica and particles of biotite, amphibole, feldspar, and mennacanite. Besides the sedimentary rocks mentioned, there is a place near the red sandstone exposure, east of Kampong Kotta Ranah, where granite has been laid bare by the last right-hand tributary of the Sungi Kalomboi for a distance of 60 to 75 feet. This granite shows, in a quartzose and albitic matrix, white muscovite and black tourmaline. Within the area exposed is a lode about 6 feet wide, of a very fine-grained granite, contrasting with the coarse inclosing granite, from which it is separated in addition by a smooth plane. It appears like a product of segregation. The composition of the two granites seems similar, but the proportion of quartz is larger in the lode. Bedding-planes are observed, suggesting what Dr. Hunt calls an indigenous granite.

The Kalomboi streams show more or less abundant traces of this rock up to the next tributary on the right, suggesting a similar exposure in the next ravine. No tin could be found in this granite. South of this and along the west banks of the Kalomboi the yellow sandstones are observable. Fragments of a similar granite were found in the Blevon and Katjang creek beds, which would indicate that a granite exists north of the Lau-Rambei divide, though diligent search failed to find it in place.

The density of vegetation makes prospecting difficult. Almost every line explored has to be previously cleared by bushmen. In view also of the limited time at the disposal of a transient explorer, the interruptions and delays caused by frequent drenching from tropical rains, and the dissuasion (from too minute examination of the jungle) furnished by occasional tiger tracks, it will be clear that a thorough study of the geology of the region was not practicable. Such a study will require long and systematic work. Briefly summarized, the red sandstones crop out southeast of the Sungi Pingir and Lau confluence, and again west of Kampong Rambei, toward the Bleoon-Rambei confluence, and south from Kampong Rambei toward Sungi Quay. All sandstone exposures found (beyond those enumerated) were a yellow sandstone, more or less decomposed by weathering, save along the upper Lau, where the indurated, reddish-gray, micaceous, and siliceous sandstones occur. It is possible that the albitic granite more generally underlies the sandstone beds of this district than is proved by the data now at hand; but it is certain that granite does not come to the surface, for no mica is found in the beds of the mountain streams.

The country north of Kotta Ranah, toward Getti, is slightly rolling for about 6 miles, the remaining 8 miles being half lowlands, half marshes and swamps. The highest altitude, according to corrected readings from a compensated aneroid, is 560 feet above the sea, and the lowest hilltop is 300 feet high, while the lowlands range from 200 feet above the sea level down to 115 feet (at Getti). The underlying formation of this north country, so far as can be judged from the color and nature of the soil on the paths, is sandstone. At and east of Getti an indurated calcareous clay, full of cypridenas and other small shells, forms the shores of the Tapong Kiri. At Batoe Gadja, about 20 feet lower, the banks and the bed of the river are indurated fine clay conglomerate. The clay matrix surrounds rounded quartz granules, from the size of a pin head to pea size, and more angular and partly kaolinized pieces of feldspar. Throughout the mass occur carbonized vegetable remains, and an imperfect impression of a shell was noticed. East of Petapahan, along the lower Tapong Kiri, sandstones occur of more recent formation than the (probably tertiary) Kotta Ranah series. Inland, up and down the Siak river and west of the town of Siak, the soil is very clayey, so much so, in fact, that tobacco growing has been abandoned on account of it.

A comparison of the foregoing account of Sumatra with what is known of adjacent countries shows that similar geological conditions have prevailed in the Malay peninsula, Karimon islands, western Borneo, Singkep, Banca, and Billiton, and as the search is extended this belt of a former geological unity will unquestionably be widened. Quartzites, quartz conglomerates, quartz schists, hornblende schists, siliceous sandstones, clay slates, with granite and local basalts (Karimon islands, according to Natuurkundig Tijdschrift von Nederlandisch-Indie, volume XLIV), form the prevailing rock formations.

In examining the Kotta Ranah-Rambei stream system and banks for alluvial tin, a universally shallow and similar alluvial covering was found. The covering over the angular quartz gravel averages 3.5 to 4 feet, and consists of about 6 inches of humus and 3 to 4 feet of yellow sandy clay. The underlying angular quartz gravel is itself divided into 2 separate layers. The upper, 8 to 10 inches, consists of angular fragments of white quartz, of 3 inches maximum and 1 to 1.5 inches average diameter, largely intermixed with carbonized wood, and contains occasionally stray pieces of fossil damar resin. It carries very small amounts of fine cassiterite and considerable magnetic and red oxide iron sand. In the lower layer, which is separated from the upper by a thin, often only slightly marked, seam of gray clay from 1 to 2 inches in thickness, the nature of the quartz gravel is the same as above, but carbonized wood is absent, the amount of iron sand is smaller, and that of cassiterite is larger. This layer is locally known as the pay seam. Small crystals, or crystalline fragments, of spinel and ruby, but no tourmaline, garnets, topaz, or mica, were noticed. The cassiterite is to a large extent semicrystalline, and crystals are by no means rare. Both the tin ore and the quartz show little average wear of corners and edges, indicating that they have been transported but a short distance only. Underlying the quartz gravel is a tough gray or greenish-gray clay of varying thickness, which gradually passes into decomposed rock in place from 3 to 4 feet thick. Below this lies the true bed rock, an impure sandstone of the nature already described. The tough gray clay underlying the quartz gravel is the bed rock for working purposes. As is usual in creek beds and their adjacent banks, unevenness in the bed or pot holes occur, in which there is generally an extra accumulation of tin ore. In figuring the thickness of the gravel and its corresponding richness they must be considered. By a simple computation (the tons of quartz gravel worked from a given area being known) it is ascertained that the average thickness of the pay quartz gravel, including the pot holes, is about 6.5 inches, or 0.54 foot, in the Batang creek, with an average overburden of 4.93 feet. This creek had been selected to begin operations on as offering the best inducements. The pay gravel yielded "black tin" (averaging 70 to 72 per cent in "white" or metallic tin) at the rate of 2.7 pounds per ton of 2,240 pounds, or 0.12 per cent. Calculated on the total amount of ground excavated, including the stripping, this would be 0.476 pound black, or 0.348 pound white tin per cubic meter excavated. In Banca, according to Van Diest, the same amount of excavation yields 2.2 to 3.33 kilograms black, or 1.75 to 2.03 kilograms (2.95 to 4.46 pounds) white tin.

The relative proportion of pay gravel to entire stratum removed is at Banca, 3 to 33 feet; at Kotta Ranah, 0.54 foot to 5.47 feet, or practically the same. The advantage of a lighter covering in the latter place is neutralized by a reduction of yield in about the same proportion. The economical limit of mining is naturally different in the 2 places, depending largely on surrounding conditions, mechanical facilities, and the cost and efficiency of labor.

In Banca, the amount of ground removed per annum by 1 man is, according to Van Diest, 300 to 450 cubic meters. At Kotta Ranah it is 205 cubic meters in cleared, dry ground, and 196.68 in cleared but ordinary ground. The average yearly product of 1 man in Banca is 610 kilograms white tin. Hydraulic stripping can not be introduced at Kotta Ranah for lack of head and grade. The maximum width of the pay channel is about 200 feet; the average probably 35 feet. The streams are short, and if mechanical devices were used in stripping they would have to be moved frequently. Pannings were made of nearly 10,000 pounds of gravel from the different creeks. 20 per cent of the pannings were rejected as too low, or as lying outside the limits of the tin-bearing channel, the remaining 80 per cent gave an average result of 1.13 pounds metallic tin to 2,240 pounds of stream gravel, or 1.75 pounds per cubic meter. The distribution of the cassiterite through the creek beds of this district is somewhat unusual in character. One would expect the fine ore to be found down stream and the coarse ore upstream, according to the laws governing the disposition of sediments; but in this examination it is found, on the contrary, a perceptible decrease in the average size of the grains, going upstream, within a certain limit or belt. Going beyond this limit there was a positive decrease, both in the coarseness and quantity of the tin grains. An absolute unsized condition, so to speak, of the tin grains in the creek beds within this belt or zone was also noticed, while outside of it the tin would either be extremely fine and but little of it, or no tin at all would occur. (Upper Lau and Rambei.) Within the belt coarse tin ore would be found in the creek beds a few feet beyond fine ore, and, vice versa, there seemed to be an utter absence of regular sizing. In some of the streams, notably the Petaling, Kalomboi, middle Quay, and upper Blevon, grains or crystals of cassiterite were found still clinging to small, angular, or sharp pieces of quartz which appeared crystalline and drusy under the microscope. This indicates that the tin ore now found in the streams has been broken down from veins of quartz not far away. In some instances (Petaling and Blevon) the veins must be very near. Considering also the angularity and size of the quartz gravel in the creek beds and banks, and the absence of mica and tourmaline, one is inclined to think the existence in the indurated sandstones of narrow quartz veins carrying cassiterite, which have furnished the stream tin, to be a not unreasonable hypothesis. By plotting the results of the test pannings a tin belt is defined with a northwest and southeast trend. This indicates that the course of the stanniferous quartz veins (from which the stream tin came) corresponds with the general axis of upheaval of the country. The nature and unsized condition of the detrital material points to an occurrence of these veins in the sandstones lying but a short distance above the marked belt, or even within it. Corroboration bordering on proof is furnished by the absence of quartz gravel in the upper Lau (toward its headwaters), and the occurrence, instead, of micaceous and fissile sandstone in pieces of rounded and angular shape. Similar but less marked conditions occur in the upper Rambei stream, while in the upper Batang and other streams all gravel disappears.

It thus appears that the Kotta Ranah-Rambei alluvial tin field is of very recent origin, being derived from the broken-down outcrops of narrow stanniferous quartz veins, which occur in the underlying and adjacent impure sandstone, in a probably northwest and southeast direction. They are likely to extend at intervals into adjoining districts. That there really are narrow quartz veins in the underlying sandstones (though what was seen was not stanniferous) was proven when a pit was sunk in the kulit of Batang creek, extending into the decomposed rock in place. A nearly vertical 2-inch veinlet of quartz was carried in one side of it. The quartz now found in the creek beds is, of course, part of the broken down outcrops of veins. The surrounding country indicates that erosion has taken place to a minimum depth of several hundred feet. The heavy tropical floods carry, as a matter of fact, the finer and lighter tin ore to the larger streams and their flood plains, and it is not surprising that traces of tin ore can be found even at long distances from their probable source. Unquestionably there exist other and similar belts in Siak. Tin ore in the streams of the northwest part of the concession and beyond, near to Rohkan river, have been heard of, but no test of their value and extent has been made. A systematic further tracing of the belt may lead to the discovery of richer fields in Siak than the one described.

For comparison some figures are introduced from another foreign field, the Kong Loon Kongsi mine, on the Malay peninsula, in the district of Kamounting, Perak, as reported by Mr. M. J. Errington de la Croix in Les mines d'étain de Pérak. A Chinese company is working the field under a concession, and the formation may be taken as typical for that district.

At this place a cross-section through the alluvium shows:

	Meters.	
Humus	0.20	Strippings, 3.5 meters.
Yellow clay	0.90	
Sand with tourmaline grains	0.70	
Gray clay	0.65	
Gravel, quartz, feldspar, tourmaline	0.25	
Reddish ferruginous clay	0.50	
Sand	0.15	
Yellow clay	0.75	
Tin deposit with bowlders	2.80	Pay gravel, 2.8 meters.

The pay gravel bed averages 1 per cent in metallic tin. From Mr. De la Croix's figures it appears that 44.4 per cent of the material excavated is useful material and the remaining 55.6 per cent is waste. He says it requires 41 cubic meters (1,600 kilograms) of pay gravel to make 1 ton of black tin ore assaying 66 per cent white metal. Hence it must require 92.48 cubic meters of excavation from grass roots to bed rock to furnish the 41 cubic meters of gravel required. This costs $1.18 (Mexican money) per cubic meter of gravel.

From other data in the report it is calculated that 1 man removes in that mine 343 cubic meters of ground per year. The work performed at the Kong-Loon mine is raising 16 kilograms (the weight of a basketful of gravel) a maximum of 6.30 inches, with a velocity of 5 centimeters per second. The day's work amounts to about 6.5 hours. The work performed is then 0.80 kilogrammeter per second, or 18,720 kilogrammeters per day. At Kotta Ranah the workmen raise only (average of 56 observations) 11.6 kilograms (25.59 pounds) a maximum of 1.72 meters, with an average velocity of 3 centimeters per second, or the duty performed is 0.348 kilogrammeter per second, or 9,605 kilogrammeters per day's work of 7.66 hours. The class of workmen and the discipline and organization are evidently superior at Perak, but the duty performed even there is only about one-third of that of white labor in temperate climates. In view of this large difference in effective work, a few words as to the system of mining labor in the east are given. The ordinary workmen employed for mining and allied occupations are Chinese, who are either imported direct by the employers or are obtained more generally through Chinese agencies, which exist in different parts of the east. These agencies import the men direct from China, at their own expense, under contract, and then sublet them to individuals or corporations, at a fixed cash price per head (supposed to cover expenses and profit of the importing agencies) and under agreed and stipulated conditions with their employers, which are signed by both parties and attested in the presence of the "Chinese protector" (a). The wages of the ordinary cooly are $30 (Mexican money) per year, $18 of which is advanced to him upon enrollment. The agency in Singapore receives in addition a cash payment of $20 for a 12-months' cooly. At the termination of his contract the laborer becomes an "old" or "free cooly" and is at liberty to re-engage of his own volition, at a previously agreed price, to the same party, or make his own terms elsewhere, or return to the town whence he came. As a novelty to American miners, a copy of one of these contract forms is given:

It is this day mutually agreed between the employer, the A. B. C. Company, his attorney, heirs, or assigns, and Tu-Tru, Chinese laborer, born at ——, and aged —— years:

That the said laborer is willing to proceed to Kotarana Sumatra and be employed there as a tin miner for 12 months, at a yearly wages of $30 subject to the following conditions, viz:

1. That the said laborer receives an advance of $18, which shall be deducted by instalments by the employer, at the rate of $1.50 per month.
2. That the expenses for conveying the laborer to his destination shall be borne by the employer.
3. That the said employer shall furnish the laborer with a suitable house, for which the latter will not be required to pay rent.
4. That the said employer shall provide the laborer with his daily food, and also furnish him with 1 jacket, 2 pairs short trousers, 1 mosquito curtain, 2 bathing cloths, 1 sun hat, and a pair of clogs.
5. In the event of the laborer falling ill from natural causes, the employer shall furnish him with medicine and a place for his medical treatment until recovery, and if the days of illness do not exceed 30 days the loss of time shall be borne by the employer, and the laborer will not be required to make up for it; but should the illness of the laborer exceed 30 days during 1 year or should he fall sick from his own fault, or contract any venereal disease, he shall, on recovery, or after the termination of his agreement, make good the days of his illness, and shall also pay to the said employer 27 cents as costs of food for each day's absence. Should the laborer desert and be captured all expenses actually incurred shall be repaid by him.
6. Should the laborer be unable to work on account of venereal disease, or stop work through laziness, the number of days of such absence, together with any advances he may have received, shall be indorsed on the contract, and should there be, at the expiration of the agreement, any sums outstanding, the laborer shall work at the rate of $6 per mensem, as in the case of old coolies, until the whole amount has been paid.

Whenever there is any dispute, the agreement shall be taken to the protector of Chinese, or, if beyond this colony, to the local authority.

7. 10 hours shall constitute a day's work, but in case of emergency the laborer shall work beyond the specified time. Such overtime shall be placed to the credit of the laborer at the rate of wages mentioned in his contract.
8. The customary Chinese festivals will be considered as holidays.

The above eight articles having been clearly explained to both parties by the protector of Chinese, they have agreed to all of them and have signed this contract with the understanding that they shall hereafter observe all the articles mentioned therein.

Register No. ——; name in English of employé, —— ——; age, ——; name in Chinese, —— ——; original country, ——; advance, $——; signature or mark of employé, —— ——.

Office of protector of Chinese, ——, 18—.

—— ——, *Employer*.

—— ——, *Witness*.

—— ——, *Protector of Chinese*.

Coolies introduced into the Dutch possessions must have their contracts filed and registered by their employers with the nearest "resident" or "assistant resident". The Dutch law does not permit coolies to be worked without a contract, and requires a proper enforcement of its stipulations. So long as coolies live up to their contract they can not be dismissed before its expiration without the consent of the "resident". This is an important matter to the promoters in case of an unprofitable enterprise. Coolies work under foremen called mandors, distinguished as first, second, third, or fourth mandor, according to their ability and duration of service and to the number of men under them. In Siak each mandor worked 50 coolies. Mandors' wages vary from $100 down to $70, $60, or $40 (Mexican money) per month. The mandors are supposed to board themselves. They are paid from 1 to 2 months' wages on account on enrollment. Mandors are picked from among "old" or "free" coolies. The wages of Chinese blacksmiths (free) vary from $20 to $25 per month, and carpenters cost, according to skill, from $15 to $25 per month.

To these wages must be added the cost of brokerage, agency, contract drawing, medical examination, and other items; also the cost of shipping coolies to their destination and feeding them en route. The monthly board, either provided by the employer direct or through a boarding-house boss (tauki), against a fixed charge, must also be included. If a cooly dies during contract time, the $20 purchase money and any part of the $18 advance not yet worked out is lost to the employer. Moreover, the time lost through sickness of less than 30 days, the cost of medicine administered (see contract), the hospital cost for patients ill more than 30 days, and the eventual funeral expenses and loss of clothing supplied, are all charges to be considered when the cost of a unit of labor is computed. The time lost during heavy rains (the coolies working out of doors), when calculated for a lot of coolies per year, represents a good many days' work. Adding to all this the necessity of breaking in raw coolies for their especial work, it is concluded that cooly labor is more expensive than might at first have been supposed.

The hours of work in Siak are from 7 to 11 a. m. and from 1 to 5 p. m. About 10 minutes are lost each time on going to work and getting ready. The cooly's work is reckoned to commence when he leaves his roof or shelter.

Coolies in Siak are paid once a month, nominally $2.50, but $1.50 is kept back on account of the advance made at enrollment, leaving the cooly $1 in cash per month during his year of employment. There are no rates per hour, such as are established for overtime in the Malay peninsula, where the whole cooly labor system, being of longer standing, is better organized and disciplined than in Siak.

a The Chinese protectors are government officers, appointed to enforce the fulfillment of labor contracts and to take the part of the wronged party, if occasion requires.

The tools of the Chinamen are a chankol, a hoe-like instrument, which takes the place of the pick and shovel, and a crowbar, for harder material or bowlders. The material excavated is filled with the chankol into small, flat rattan baskets (bakol), which are carried across the shoulders, being hung back to back, so as to be easily dumped by either hand. Notched poles, similar to those used in Mexico, serve as ladders in the pits.

To raise small quantities of water, or to hoist from the deeper pits, the old-fashioned "well-sweep" is used, with a thin rattan vine for a cord, carrying for the former purpose a bucket, for the latter a larger bakol than is used for carrying dirt and gravel by hand. The Chinese pump is also employed. Steam pumps have been introduced in the Malay peninsula.

In addition to the Chinese miners, small numbers of Javanese coolies are employed in Siak for making roads and grubbing out the roots of trees, and the native Malays find work in clearing the jungle and forest, carrying supplies over the rough roads, building native huts, cooly houses, stockhouses, etc. The Javanese coolies are, like the Chinese, under time contracts, but they feed themselves, procuring supplies from the natives. The Malay workmen are free men, independent in their actions and character, and better suited to their special work than either of the other 2 races. The 3 races live apart, and there is no love lost among them. Malays are paid 33.3 cents a day, and feed themselves.

Storehouses, cooly houses, etc., are framed of rough timbers and heavy sticks, the sides being of bamboo laths covered with bark or atap (a variety of palm leaf). The floor is made of closely-laid bamboo sticks, and the roof is covered with atap. The following example shows the number of days' work required to build, as far as the lower edge of the roof, a storehouse (godang) 14 meters long, 8.5 meters wide, and 2.7 meters high, and raised on posts 1 meter high from the ground. The jungle was cleared for a considerable distance around the house.

	DAYS' WORK.
Clearing jungle	24
Grading	46
Cutting and carrying to camp:	
Timbers	326
Sticks	49
Atap	350
Rattan vine	150
Bark	12
Bamboo	57
Extra wall material	41
Preparing atap in camp	262
rattan in camp	154
wall material in camp	120
Labor of erection	364
Total	1,955

At 33.3 cents equals $651.66.

A dwelling house, 11 by 8.5 by 2.3 meters, with kitchen attached, 5 by 5 by 2.5 meters, cost 324 days' work. Both buildings were rain proof.

The Banca miners of alluvial tin distinguish two classes of work: the mountain stream work, called kulit, and the working of valley placers and flats, called kollong. From this has also grown the custom of calling work on an upper gravel layer kulit, and on a lower one kollong; work on an intermediate layer being called kulit-kollong. In Siak, Sumatra, kulit work only exists. This work is performed, after the necessary preliminary cleaning and grubbing, by Chinese coolies, and consists in first diverting the stream and then making upstream a series of rectangular excavations (kulit), taking in, if possible, the full width of the pay channel or working from bank to bank down to and through the pay gravel, but keeping the strippings separate. After staking off a rectangle of the width of the gulch or pay channel, and, say, 100 feet in length, a number of Chinamen are placed, chankol in hand, along the lowest line across the gulch, facing upstream. These loosen the ground and fill it into the baskets of the stripping carriers (angkat tanna), who stand behind the diggers (chankol tanna) and have to carry the waste back of the field to the dumping ground. When the staked area has been stripped down to the pay gravel or karang, this is taken out similarly and carried to the ore or karang floor (a). A new pit is then commenced, and the strippings of the new work are dumped into the first excavated and now empty pit. When the work is in full operation there are distinct squads of strippers and pay-gravel diggers with their respective squads of carriers, distinguished as orang tanna and orang karang. The gravel is constantly tested, at different places, by washing (in the batea) to guide the diggers.

As already observed, the baskets at Kotta-Ranah in which the material is carried out of the pits are small, holding only 25 pounds; in Perak the carrier's load is 35 pounds, and in Pahang 37 pounds. If light iron wheelbarrows were substituted, and planks laid to wheel on, a carrier, in these shallow deposits, could just as easily wheel out from 60 to 70 pounds in the time he now consumes in carrying 25 pounds. The Chinaman, however, dislikes any innovation upon his accustomed ways, and much prejudice was encountered on the part of the mandors when the trial was suggested. They were, however, finally persuaded and convinced that the assertion was correct; but it was soon learned that, besides prejudice, superstition had to be overcome with the Chinese tin miner. The tales of mining kobolds and gnomes still hold full sway in their minds. They believe that tin is under the especial protection of gnomes who are easily offended, and who, if established ways are not strictly adhered to, leave the mine and take the tin with them. One very disagreeable thing exacted by these gnomes is that when karang is being dug no one shall enter the kulit except barefooted. Now, this is the most interesting stage in the work for one who wants to study the deposit, and it surely tries an expert's enthusiasm to be obliged to walk barefooted over muddy angular quartz gravel for each sample to be panned. Again, while pay gravel was being dug, it was not permitted to approach the ore floor or the kulit with an opened umbrella to shield against rain or the tropical sun. The mandor said "the tin would leave the gravel over night". At each starting of a new kulit, or of the wash machine, tapers were burned at each end, formulæ were said in Chinese, and the wash machine was treated to a handful of rice, carefully dropped into the feed water. It required patience and time to overcome these superstitions. Though impressed by the washing of tin out of the gravel in a gold-miner's pan, the coolies did not give their confidence until a prospecting borer was brought out and started, which, to their surprise, brought up tin without stripping in the regular way. It was permitted after this to keep one's shoes on, but still one had to forego the luxury of an umbrella about the diggings.

Another evidence of either superstition or extraordinary mutual affection is presented by the death register. Each cooly receives a number on enrollment, which is carried for identification; in addition, each man is photographed, and his number is written on the picture. Friends generally take consecutive numbers. I was struck to see how death selected certain sets, nearly by consecutive numbers, such as 9322, 9324, 9325, 9326, 9328, 9344, 9346, 9347, 12513, 12515, 12517, 12519, 12520, 12541, 12542, 12543.

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a Karang really means "rock", and is used in this connection as our lode miners speak of "pay rock", in contradistinction to tanna or earth. Angkat means carrying or carried.

The simple and crude borer used in the east for prospecting alluvial deposits consists of a circular iron platform with a central annular opening, and a projecting sleeve on the under side large enough to slip over the casing tube, to which it is held by 3 heavy screw bolts. The casing has couplings with slot key seats or common screw couplings. The pipe used was 3.5-inch cast iron, with a projecting steel shoe for the end piece. Boring-rods were 1.5-inch square bar iron, with a screw socket top. The bit of the boring tools is 3 inches in diameter, there being a variety of bits in each outfit. Besides a large auger to start the casing hole, there are screw augers, augers with ball valves, screw-nosed cylinders with ball valves, a T-shaped wood-cutting chisel, semicircular, cross, and flat chisels for rock or bowlders, crown borers, sand borers, and a variety of other tools, such as rod catcher, spring darts for tubing, etc. These tools might be much improved. The price of such an outfit at Singapore is about $685 (Mexican money). In the iron platform, arranged along the circumferences of a series of concentric circles described about the central coupling, are a number of 1-inch holes intended to permit the attachment of weights to the platform by means of hooks or lashings. When the casing has been started several feet into the ground, and a guiding frame has been built about it, 4 men mount the platform, insert the boring tools into the casing, and, walking in a circle, turn the rods by means of hand dogs. The weight of the men and platform plus the weights attached below forces the casing down as the boring tool cuts the material away. The casing, which is fastened to the platform, turns in an opposite direction from the borer by virtue of the circumstance that the men brace their feet simultaneously against the platform as they press on the hand dogs. To guide the rods and to facilitate the lengthening and extraction of rods and tubing, a tripod, rigged with blocks and falls, is erected over the bore hole. The number of feet bored per hour varied according to the nature of the ground and the kind of bit. With an entirely raw crew, the average progress was from 1.33 to 2.06 feet per hour, and the time occupied in loosening, extracting, lengthening rods and tubes, etc., and necessary delays varied from 2.27 to 11.9 times the actual boring time. The average progress of 1.33 feet corresponds to the smaller ratio of 2.27 just given. In this case a cylindrical open shell with screw-nosed end was used as a bit. When 2.06 feet average progress was made per hour a regular screw auger was used. This would tighten frequently, and the necessary delays amounted to nearly 12 times the actual boring time, but the net rate of progress was greater. In both cases the soil was a tough, gray clay. The depth of holes varied from 11 to 32 feet. The crew comprised 11 men, 4 on the platform, 6 extracting, handling rods, tubes, etc., and 1 panning the borings.

In Banca and Billiton, where the coolies have been trained for years by Europeans, conditions are different. In Billiton there is a regular boring corps in charge of European engineers, which tests the fields systematically in advance by boring first at intervals of, say, 100 yards, and supplementing these with holes 20 to 25 yards apart, or closer, if necessary, to ascertain the course, average thickness, and character of pay gravel. The contents of each bore hole are carefully washed, the collected tin is weighed, and calculations are made as to the probable yield. On the basis of this estimate the fields are let out to Chinamen, against a fixed price per unit weight of tin produced (*a*) and turned over to the company.

It has been established that the average wages expended in Billiton per pikol of tin ore produced is 20 guilders, and that 12 guilders per pikol is the cost of administration, etc. On the basis of these figures and the indications of the test borings a certain tariff is figured out, with contingent bonuses.

Under a former tariff the basis of wages was 20 guilders per pikol of tin ore, but the workman received, as minimum wages per annum, 140 guilders, or the pay for 7 pikols, whether he produced so much or not, 7 pikols being the lowest rating of annual yield per man. If he delivered the full rated quantity or more, he received a bonus determined in a sliding scale, in addition to the regular wages of 20 guilders per pikol. The sliding scale was as follows: for ground rated to yield annually 7 pikols per man, the bonus paid, besides wages, to each man delivering the rated quantity or more was 80 guilders; for 8-pikol ground 65 guilders, 9-pikol ground 50, 10-pikol ground 35, 11-pikol ground 20, and 12-pikol ground 5 guilders as bonus. The reward, as will be seen, is very properly largest for the man working in the poorest ground, as workmen in richer ground, even if they do not secure the bonus, are pretty certain of getting more than the guaranteed minimum of 140 guilders. The present minimum in Billiton is 120 guilders per year, representing 6-pikol ground, and the above sliding scale has probably been correspondingly altered. The pay gravel at Kotta Ranah is sufficiently free from clay not to require puddling. It is washed in a sluice box 18 feet long, 3 feet wide at the head and 1 foot 5 inches wide at the tail, having a slope of 3°. Above the sluice box a cylindrical sizer, 1 foot 6 inches in diameter and 3 feet long, made of 0.5-inch square bar iron, and having a slope of 1 inch to the foot, is connected by shafting with an overshot water wheel. Three-fourths of the water required in sluicing is passed in with the gravel at one end of the drum, the remaining quarter drops from above from a perforated launder onto the revolving drum, which it enters through the 0.25-inch spaces, washing the coarser gravel clean. The coarse gravel is discharged at the opposite end of the drum, which has a turned-up flange 0.5 inch high, to prevent a too rapid discharge of the gravel and insure a better washing. The fine stanniferous gravel falls through the 0.25-inch spaces upon an apron 2 feet 5 inches long, inclined 23°, and provided with distributors. This apron is continued for another foot, to the head of the sluice, but at 60° inclination. The gravel is raked with a flat, narrow wooden shovel or with forks, and is afterward skimmed. The concentrates are cleaned in the batea. This combination of sluice and sizer was copied from Australian mines.

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a The unit of weight on which tin ore is bought and sold in the East Indies is the pikol. The following table of native weights is compiled from the Netherland Indies government almanac for 1890:

		KILOGRAMS.
1 pikol = 100 katties	=	61.763
1 kattie = 16 thails	=	0.616
1 thail precious metal	=	0.054
1 koyan = 28 pikols (Samarang)	=	1,729.316
1 koyan = 27 pikols (Batavia)	=	1,667.555
1 koyan = 30 pikols (Soerabuja)	=	1,852.839
1 koyan = 30 pikols (Batavia, for salt, etc.)	=	1,852.839

The following are the figures for the Malay peninsula, as given by E. de la Croix:

		KILOGRAMS.
1 pikol = 100 katties	=	62.500
1 kattie = 16 thails	=	0.625
1 thail	=	0.039
1 bharra = 3 pikols	=	187.500
1 koyan = 40 pikols	=	2,500.000
16 pikols = 1 metric ton	=	1.000

At Singapore:

1 pikol white tin metal = 60.5 kilograms = 133.33 pounds avoirdupois.

16.8 pikols = 2,240 pounds avoirdupois = 1 ton.

The capacity of such an apparatus, when the gravel is not clayey, was found to be 5,826 pounds wet or 5,194 pounds dry gravel per hour. This average was obtained from a run of 174,786 pounds of weighed gravel.

The labor required for washing and weighing per day was: 1 man at ditch; 1 man wheeling away tailings; 1 man taking away coarse gravel and attending to transmission of power, etc.; 4 men washing; 2 men feeding drum on ore floor; in all, 9 men; 1 man weighing ore; 2 men carrying weighed ore to drum floor, and half the time of 1 mandor. It will easily be seen that with proper arrangements at least 4 men could be dispensed with. Tailing samples from the sluice box contained 0.2 pound of black tin per ton of pay gravel. Singapore smelting charges, on long time contracts, are indicated by the appended sliding scale:

Ore assaying 70 per cent and over, gross price $1.50 per pikol, or $25.20 per ton.
Ore assaying 65 per cent and over, gross price $1.75 per pikol, or $29.40 per ton.
Ore assaying 60 per cent and over, gross price $2.00 per pikol, or $33.60 per ton.

Ores containing sulphur, copper, or iron pyrites, arsenic, or other impurities, requiring special treatment, must be specially arranged for. The charge for roasting is 55 cents per pikol extra. The deductions are, first, a small percentage for impurities, and then for loss in furnace. Deductions for trifling impurities usually vary from 0.2 to 0.5 unit, and for smelting losses the deductions are:

On ore assaying—	DEDUCTION. (Units.)
70 per cent and upward	2
65 per cent and upward	3
62 per cent and upward	4
60 per cent and upward	5

For example, on a high-class ore, assaying, say, 74.2 per cent of tin, there would probably be deducted 0.2 for impurities and 2 units for loss in furnace, leaving 72 per cent net refined tin. On ore assaying 72 per cent and quite pure, possibly 70 per cent net refined tin would be allowed, but more likely 69.5 per cent. It will be seen that the losses thus charged are quite severe when the ore falls below a 70 per cent grade. Assuming the deduction for impurities at 0.5 unit, the losses charged really are:

For ore assaying—	PER CENT.
70 per cent and over	3.57
65 per cent and over	8.46
62 per cent and over	10.46
60 per cent and over	12.50

The smelters use furnaces similar to those of Cornwall. There should be a handsome profit in these charges. Their only competitors are the Chinese smelters in the local camps.

Mr. E. de la Croix gives the rates at Perak. The tin ore there is pure but fine, and contains no arsenic and seldom sulphur. An analysis of the Kong-Loon mineral shows tin, 66; iron, 6.15; silica, alumina, etc., 27.85. The single smelting, which suffices for the reduction of the stannic oxide to metal, is performed in a low semicylindrical shaft furnace (spurofen) of brick, 45 centimeters in diameter and 1.85 meters high above the hearth level, with 1 tuyère inclined 40° to 45°, the whole costing about $100. Smelting is done at night; 36 pikols, or 2.25 metric tons, of mineral are treated per night, with a consumption of 1,203.125 kilograms of charcoal (53.47 per cent). The costs per pikol are $0.55 for labor and $2.30 for fuel, a total of $2.85. The losses in treating 66 per cent mineral are 7.60 per cent (much of the mineral being very fine). The slags made are ground and washed for metallic granules, or sold to special smelters. Mr. De la Croix gives the following analysis of washed and unwashed slags:

COMPONENT PARTS.	Unwashed slags. (Per cent.)	Washed slags. (Per cent.)
Tin (metallic granules)	5.30	55
Tin silicate	8.60	15

This shows that much of the silicate of tin was lost in washing.

The Chinese-built furnaces of Billiton are made of clay. A similar one was seen in Sumatra. They are short, cylindrical shaft furnaces, 12 to 15 inches in diameter, and 3.5 to 5 feet high from lowest hearth level to throat. The hearth bottom is spherically rounded, and a tuyère hole is provided above for artificial blast.

The Chinese generally smelt during the 4 months of the wet season, from December to April, and during the night. They commence preheating the furnace at about 3 p. m., charge at 7, and at 9 the charge is fused. The campaign of a set of 2 furnaces, costing when erected about 200 guilders each, is, say, 2,000 pikols, which are run through in 80 to 90 nights. Hence the furnace wear per day is about 5 guilders. 27.5 pikols smelted is considered a large night's work. The cost is about 2 guilders per pikol, or per day 53 guilders, divided as follows: Fuel, 40; wear and tear, 5; wages, 8. The latter item includes 1 head smelter, 4 assistants, 3 bellows men, and 2 roustabouts, making 10 men, at average wages of 25 florins per month.

Only about one-fourth of the Billiton tin requires refining. The black tin averages 71 per cent in white metal, and the loss in smelting was given at about 3 per cent.

What is known to the trade as Singapore tin comes partly from Perak, partly from Sungi Ujong, Selangor, Kwalla Lumpur, Jelubu, and Malacca. Pahang is expected to add to the Singapore output hereafter. What is known as Penang tin is all from Perak (part of the Perak tin goes to Singapore). What is known as Straits tin in London is Penang and Singapore tin. What is known as Malacca tin in the United States is also Penang and Singapore tin, only it is specially branded to satisfy the American buyers. It may seem strange that Penang tin is sent to Singapore in preference to exporting it direct, since freight rates from Penang to Singapore are 8 cents per pikol; insurance, 0.125 per cent; exchange and banker's commission, 0.125 per cent additional. If tin is quoted in Singapore at, say, $31.50 per pikol, the extra shipping, costs, etc., from Penang would be 16 cents per pikol. Singapore overcomes this drawback of 16 cents by having better shipping rates and more favorable banking facilities. The shipping rates in September were as follows: To Holland, 15 shillings per ton; to United States, 21 shillings; to London, 7 shillings 6 pence. Insurance costs 0.250 to 0.375 per cent.

The mines of Cornwall and Devonshire furnish nearly one-fifth of the total supply. These mines are too well known to require description. They furnish the principal guide as to the lowest limit which can be reached in the percentage of tin in the ore with a resulting profit in the mining, even where the cost of wages, etc., is low.

PRODUCT OF TIN STUFF (CRUDE ORE) AND ITS PERCENTAGE OF METALLIC TIN FROM CERTAIN ENGLISH TIN MINES.

YEARS.	Number of mines.	Tin ore. (Short tons.)	Black tin. (Short tons.)	Per cent of black tin.	Metallic tin. (Short tons.)	Per cent of metallic tin.
1883	15	8, 203	159	1. 94	102. 27	1. 24
1884	9	4, 508	66	1. 46	41. 80	0. 93
1885	8	2, 367	78	3. 30	50. 66	2. 14
1886	12	3. 468	87	2. 51	56. 92	1. 64
1887	15	3. 812	102	2. 68	66. 72	1. 75
1888	13	3, 653	68	1. 86	43. 72	1. 20
1889	20	6, 497	134	2. 06	86. 48	1. 30

TOTAL PRODUCT OF BLACK TIN AND ITS YIELD IN METALLIC TIN IN CORNWALL AND DEVON COUNTIES, ENGLAND.

YEARS.	BLACK TIN.		METALLIC TIN.		YEARS.	BLACK TIN.		METALLIC TIN.	
	Quantity. (Tons.)	Value. (Pounds sterling.)	Quantity. (Short tons.)	Value. (Pounds sterling.)		Quantity. (Tons.)	Value. (Pounds sterling.)	Quantity. (Short tons.)	Value. (Pounds sterling.)
1859	10, 180	731, 315	6, 497	850, 452	1875	13, 995	735, 606	9, 614	866, 266
1860	10, 400	812, 160	6, 656	866, 306	1876	13, 688	600, 923	8, 500	675, 750
1861	10, 963	793, 698	7, 016	857, 706	1877	14, 142	572, 763	9, 500	695, 162
1862	11, 841	777. 396	7, 578	879, 048	1878	15, 045	530, 712	10, 106	663, 080
1863	14, 224	943, 387	9, 104	1, 065, 168	1879	14, 665	586, 600	9, 532	689, 163
1864	13, 985	881, 031	9, 295	995, 029	1880	13, 737	673, 113	8, 918	813, 767
1865	14, 122	782, 284	9, 038	873, 659	1881	12, 898	696, 492	8, 615	839, 639
1866	13, 785	667, 999	8, 822	781, 849	1882	14. 170	813, 003	9, 300	992, 310
1867	11, 066	549, 375	7, 296	670, 228	1883	14, 469	735, 189	9, 307	903, 476
1868	11, 584	641, 137	7, 703	756, 494	1884	15, 117	669, 254	9, 574	809. 740
1869	13, 883	889, 378	9, 356	1, 138, 488	1885	14, 377	662, 390	9, 331	833, 803
1870	15, 234	1, 002, 357	10, 200	1, 299, 505	1886	14, 232	780, 302	9, 312	944, 470
1871	16, 898	1, 068, 733	11, 320	1, 556, 557	1887	14, 189	878, 831	9, 282	1, 048, 633
1872	14, 266	1, 246, 135	9, 560	1. 459, 990	1888	14, 370	894, 665	9, 241	1, 083, 700
1873	14, 885	1, 056, 835	9, 972	1, 329, 766	1889	13, 809	729, 213	8, 912	860. 342
1874	14, 039	788, 310	9, 942	1, 077, 712					

AUSTRALIA.—The discovery of stream tin in Australia and its subsequent rapid development attracted great attention while the stream-tin deposits remained rich, but as the best portions were rapidly exhausted the region has taken a minor position on account of the inability or disinclination of the miners to attack the lodes from which disintegration furnished the rich stream deposits.

NICKEL AND COBALT.

NICKEL AND COBALT.

During the year 1889 ores containing nickel and cobalt were produced at Lancaster Gap, Pennsylvania, at Mine La Motte, Missouri, and at Lovelock station, Nevada. The great feature of the year was the diversion of all attention in nickel mining to the nickel-bearing copper ores of the Sudbury region in Canada. The course of development showed conclusively that nickel can be produced there for a less cost than anywhere else in the world, so far as the present capacity of the known mines permit of an opinion. In spite of the fact that this favorable outlook for nickel production in Canada has kept the more experienced nickel producers from investing elsewhere, there has been much activity in prospecting for nickel at various points in the United States, owing to the successful tests of armor plates of nickel steel.

NICKEL MINING IN THE UNITED STATES.

The following statements in relation to nickel mining show the number of employés engaged in this industry in 1889, rates of wages and number of days worked, expenditures, capital invested, power used, and the product and value of nickel:

EMPLOYÉS.

CLASSIFICATION.	Number.	Usual rate of wages.	Number of days worked.
Total	187		
Above ground:			
Foremen	2	$2.61	201
Mechanics	16	2.02	215
Laborers	85	1.11	262
Boys	10	0.60	299
Below ground:			
Foremen	2	3.30	336
Miners	33	2.45	265
Laborers	33	1.40	274
Office force:			
Males	6		

EXPENDITURES.

In wages	$84,200
Paid to contractors	2,000
Paid to office force	9,600
Total	95,800
Paid for supplies	29,236
Other expenditures	1,151
Total expenditures	126,187

CAPITAL.

In land	$184,800
In buildings	43,200
In machinery	51,000
Total	279,000

POWER.

Number of boilers	6
Aggregate horse power	140
Number of steam engines	6
Animals	54

PRODUCT AND VALUE.

Product in matte (short tons)	1,151
Total value of matte at the mines	$40,000

It will be seen from the foregoing that the mines of the United States furnished 1,151 short tons of matte, which was valued at $40,000 at the places where it was produced, which was in every case at the mine itself, without more than local transportation charges. This stage in the valuation is taken because it is desirable to show, under the items of labor and wages, the expenditures for working mines of the United States, and as soon as the product goes to the next stage it meets the heavy cost of refining to metallic nickel, which is a distinct industry apart from mining, and, moreover, at this stage the product of the United States mines loses its identity by mixture with the mattes from Sudbury, Canada. It will be seen at a glance that the cost of producing the matte bore no relation to the market value. This is principally because in the year 1889 large expenditures were made in development work, from which no sold product resulted, and this will go toward swelling the receipts of a later year, when the ores which the development work placed ready for commerce shall have passed through the smelter's hands into trade. Nevertheless, if the purely development work was excluded, the result would show a loss on the matte sold. This is because of the competition of the cheaper Sudbury matte, which makes the market price for matte. The fact that ores developed in work on the arsenide deposits of Nevada remained unsold leaves room for interesting speculation as to what might have been the result if these ores had been smelted. In this speculation it is a useful consideration that the regular mining work hitherto done has spasmodically developed irregular lots of ore rich beyond any comparison with the low-grade but steadily-produced ore of Lancaster Gap and even Sudbury, Canada, and such specimen mines do not with any regularity prove illusory when large-scale development and intelligent selection are brought to bear. On the other hand, it may also be remarked that these Nevada prospects have been investigated time and again during the past 10 years or more.

The metallic nickel produced from the matte given above, which constitutes the yield from ores of the United States, amounted to 217,663 pounds, accompanied as a by-product by 12,955 pounds of the pigment cobalt oxide. But in addition to this the nickel-refining works were concerned with a product of 35,000 pounds of nickel from the mattes of Canadian mines, making in all 252,663 pounds as the product of the nickel smelters of the United States, and worth as metallic nickel in New York or Philadelphia $151,598.

The impression has gone out that a small amount of platinum might also be obtained from the Canadian matte, but this does not seem to have been the case.

OCCURRENCE.

The nickel deposits of the United States have frequently been described. Nickeliferous pyrrhotite occurs at many places, and particularly at Lancaster Gap, Pennsylvania, where the principal mining has been done for many years. It is also found with millerite at the Rabbit Foot mine in Saline county, Arkansas; in slight amount in the Black Hills in South Dakota, and has been reported from several localities in California. The silicate of nickel is found in narrow seams near Webster, North Carolina, and there seems to be a large area in that state in which a chrysolitic rock can be found, which is stained with oxidized nickel compounds. At Riddles station, Oregon, a deposit of nickel silicate has been found similar to that at Webster, North Carolina. The deposit is new, and little work has been done on it. It was not active in the census year. A third class of ores has been worked on for some years and is still the object of considerable attention in Churchill county, Nevada. Here several lodes containing the arsenides of nickel and cobalt have been opened. The ore seems to be unusually rich, though little is known as to its persistency. The deposits have been well described by Mr. C. A. Hitchcock in a letter to the Census Office, from which the following synopsis has been taken:

The nickel mines are located 41 miles east from Lovelock, a station on the Central Pacific railroad, in Cottonwood cañon, Table Mountain mining district, Churchill county. The cañon is on the east side of the range, and opens out into a wide valley. The country rock is slate, porphyry, and granite, covered in some places by porous limestone, which must have been deposited subsequent to the erosion of the cañon, as in many places it extends down to the stream at the bottom. About 5 miles down the cañon is a dike of iron ore, possibly 400 feet higher than the bed of the stream, and running nearly east and west. It extends about 1.5 miles in length. At short intervals this dike is crossed at varying angles by veins of a siliceous nature, which cut completely through the dike, and can be traced for some distance on either side, from 10 to 40 rods. Where these cross-veins intersect the iron dike is found the richest nickel and cobalt ores, and at these points most of the work of development upon the mines has been done.

Some openings have been made along the dike at other points than those mentioned, sufficient to demonstrate the presence of nickel. Also, these short cross-veins have been similarly prospected, and in almost every instance found to carry ore. Nearly all the vein matter in these mines carries ore, but along the foot and hanging walls and in pockets throughout the center of the veins occurs the high-grade ore, from 5 to 7 feet thick on the walls, and from a few pounds to 50 tons in the pockets, and occasionally the veins open into chimneys, which are invariably high-grade ores. The dike where it has been cut shows a width between walls of 48 feet, and the cross-veins vary from 10 feet to 50 feet in width at the intersections with the dike. The paying nickel ores are, as far as present discoveries have been made, confined to this limited locality, say 1.5 miles in length and one-fourth to one-half mile in width. Other discoveries have been made, but generally the ores are associated or combined with refractory matter and of a much lower grade.

About 30 locations have been made upon the dike and cross-veins, each being 1,500 by 600 feet, under the United States mining laws.

At the eastern end of the main dike the National Nickel Company has 2 claims, and upon the dumps are several hundred tons of ore, which are said to assay from 20 to 75 per cent of nickel. Several tunnels have been run into the hill under the iron capping following the ore, and only the ore cut by these tunnels has been removed from the mine. (a) About 100 perches west of the National Nickel Company's mines Mr. George Lovelock, sr., the discoverer of the mines, began work at a cross-vein on the location known as the Emperor in 1883. The work was continued until 1886, when the steam boiler gave out, and nothing has since been done except the assessment work required by the mining laws. At this point and at 2 other points on the adjoining claims to the west he took out and shipped 300 tons of ore of a high grade. He also set up a small 5-ton water-jacket furnace in 1885, and from this shipped matte to the amount of 34,000 pounds. The ore shipped by Mr. Lovelock assayed from 20 to 60 per cent nickel, and the matte which he shipped from the ore reduced assayed 36 per cent nickel and 34 per cent cobalt. The smelting of these ores was done in a very crude and unsatisfactory manner, by inexperienced and consequently incompetent hands. To this fact the dump testifies, for nickel melted from the ore can be found in globules from the size of a pea to the dimensions of a walnut all through the slag from the furnace. On the Emperor, at the point mentioned, 1 shaft has been sunk to the depth of 150 feet on the foot wall, cutting rich ore all the way down, and 1 shaft sunk to the depth of 50 feet on the hanging wall, also in the good ore. Both these shafts are now filled with water.

At the west end of the President, the adjoining claim, some ore was shipped, as also from the next claim west, the Empire. Both these claims show a good, strong vein. Upon a cross-vein near the President Mr. Kellogg has a claim, upon which an adit has been run about 150 feet. The ore from this tunnel is piled upon the dump. Several other claims are developed on a small scale, but no systematic mining has been done.

FOREIGN NICKEL ORES.

CANADA.—By far the most important developments to be considered in connection with the ability of the United States to produce nickel are those in the neighborhood of Sudbury, Ontario. Here, in the oldest archæan rocks, large masses of pyrrhotite are found, containing nickel to the extent of 2.5 per cent, and sometimes more. The ore contains also chalcopyrite scattered through it, so that it yields about 5 to 7 per cent of copper. It was known as early as 1846, through a report to the Canadian government, that this was a promising region for copper ores, and it was for copper that the mines were first exploited. Mr. S. J. Ritchie, of Cleveland, Ohio, made application for a territory of about 100,000 acres, in an irregular territory about 25 miles long and from 3 to 7 miles wide. This was afterward considerably reduced. The Canadian Copper Company was organized in 1886 to develop this property, and has opened 3 mines, the Stobie, Evans, and Copper Cliff, each of which is typical of a distinct kind of deposit. Besides the property of the Canadian Copper Company, the Dominion Copper Company has opened the Blezard, Worthington, and Creau mines, and Sir H. H. Vivian owns the Murray mine, 2.5 miles northwest of Sudbury. The mines are well developed and are equipped with 2 water-jacketed furnaces belonging to the Canadian Copper Company, and one each to the other companies. The total yield of metallic nickel from the mattes from these mines aggregated 2,500,000 pounds in 1889, and 1,336,627 pounds in 1890, according to the division of mineral statistics of the Canadian geological survey. These Canadian mines have been fully described by Dr. E. D. Peters in the report of Mineral Resources of the United States and in volume XVIII of the Transactions of the American Institute of Mining Engineers.

NEW CALEDONIA.—The discovery near the close of the last decade that large quantities of nickel silicate exist in New Caledonia caused a sensation among nickel producers. It resulted in the formation of the well-known Société Anonyme le Nickel in Paris, and in the development of the mines which have since been the dominant supply of the world. The product of nickel was increased and the price depressed in the hope of a greater expansion in the consumption. This did not come, and the production was restricted. At present the mines are less influential than those in Canada, for although the ores are fully as rich, labor is not so good, and for imported laborers the climate is bad. The ores are found in V-shaped pockets in serpentine, which is found over two-thirds of the island. Many of the pockets are large, but narrow with the depth. The cost of mining is considerable, and the transportation facilities to the seacoast are poor. It is not probable that the mines can compete successfully with the Canadian. Lately manganiferous iron ores have been mined and shipped to Rouen for the purpose of extracting the oxide of cobalt, which they contain to the extent of 3 per cent, together with 2 per cent of nickel. This is doubtless for the purpose of securing a product with which nickel ores of Canada can not compete, as they do not contain a significant proportion of cobalt.

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a This information as to underground work was obtained through the courtesy of the superintendent, Mr. Charles Bell.

PRODUCT OF NICKEL IN PREVIOUS YEARS.

The world's consumption of nickel has amounted annually to about 1,000 tons. New Caledonia has contributed the larger part in the last 10 years, displacing considerable amounts from Norwegian mines. The total amount produced in 1889 aggregated 2,000 short tons.

The product of the United States since 1876 has been as follows:

PRODUCT OF THE UNITED STATES, 1876 TO 1889.

[Pounds.]

YEARS.	Value.	Total.	Metallic nickel.	Nickel in matte.	Nickel in ore.	Nickel in nickel ammonium sulphate.
1876	$523,554	201,367				
1877	301,138	188,211				
1878	165,979	150,890				
1879	162,534	145,120				
1880	257,282	233,893				
1881	292,235	265,668				
1882	309,777	281,616	277,034	4,582		
1883	52,920	58,800	6,500	52,300		
1884	48,412	64,550		64,550		
1885	179,975	277,904	245,504	14,400	18,000	
1886	127,157	214,992	182,345	20,000	5,600	7,047
1887	133,200	205,566	183,125	10,846		11,595
1888	127,632	204,328	190,637		1,000	12,691
1889	151,598	252,663	209,763	42,900		

In addition to the local product, the United States has always imported nickel. The imports have been as follows:

NICKEL IMPORTED AND ENTERED FOR CONSUMPTION IN THE UNITED STATES, 1868 TO 1889, INCLUSIVE.

YEARS ENDED—	Total value.	NICKEL.		OXIDE AND ALLOY OF NICKEL WITH COPPER.	
		Quantity. (Pounds.)	Value.	Quantity. (Pounds.)	Value.
June 30, 1868	$118,058		$118,058		
1869	134,327		134,327		
1870	99,111		99,111		
1871	52,044	17,701	48,133	4,438	$3,911
1872	27,144	26,140	27,144		
1873	4,717	2,842	4,717		
1874	5,883	3,172	5,883		
1875	3,193	1,255	3,157	12	36
1876	10			156	10
1877	10,346	5,978	9,522	716	824
1878	16,684	7,486	8,837	8,518	7,847
1879	13,399	10,496	7,829	8,314	5,570
1880	66,069	38,276	25,758	61,869	40,311
1881	122,130	17,933	14,503	135,744	107,627
1882	143,660	22,906	17,924	177,822	125,736
1883	132,484	19,015	13,098	161,159	119,386
1884	129,733			*a*194,711	129,733
1885	64,166			105,603	64,166
Dec. 31, 1886	*b*141,546			277,112	141,546
1887	*c*205,232			439,037	205,232
1888	*d*138,290			316,895	138,290
1889					

a Including metallic nickel.
b Including $465 worth of manufactured nickel.
c Including $879 worth of manufactured nickel.
d Including $2,281 worth of manufactured nickel.

The imports have been partly balanced by exports in the form of matte and speiss, as follows:

VALUE OF EXPORTS OF NICKEL AND NICKEL ORE OF DOMESTIC PRODUCTION FROM THE UNITED STATES.

YEARS ENDED—	Manufactured nickel.	Nickel coin.	Nickel ore.
June 30, 1864			$25,494
1865			36,710
1869			11,350
1872			43,500
1873	$19,780		19,891
1874	16,062		75,696
1875	26,000		72,020
1876	168,050		35,100
1877	8,200		
1878			2,452
1880	4,120		
1881	6,600	$32,880	
1882	12,474	7,200	
1883	9,911		a12,182
1884			a22,249
1885	1,223		10,500
Dec. 31, 1886	45,653		5,700
1887	39,209		7,500
1888	38,951		625
1889			

a Classed as "nickel and cobalt ore".

USES.

In addition to the consumption for german silver, plating, and coinage, great efforts have been made to extend the use by the manufacture of rolled nickel plate and malleable nickel, and finally by adding a small percentage to steel. This last effort seems to have been successful. The report of Mr. James Riley to the British Iron and Steel Institute showed that an alloy of about 4 per cent of nickel in steel could be made with fairly even composition, and that the result was a general improvement of the steel, particularly in toughness and breaking strain. This was followed by several private tests of armor plates of this steel. In September, 1890, a board of ordnance officers of the United States navy, with Rear Admiral Kimberly as president, made a competitive test of 3 plates, 1 of the usual compound plates made by Messrs. Cammell & Co., Sheffield, 1 of steel, and 1 of steel containing about 3 per cent of nickel, both made by Messrs. Schneider & Co., of Creusot. The proving was conducted by Ensign R. B. Dashiell. "Each plate was attacked with 4 6-inch holtzer shells of 100 pounds weight and having a velocity of 2,075 foot-seconds, and 1 8-inch firming shell of 210 pounds weight and having a velocity of 1,850 foot-seconds, the points of impact being at the 4 corners for the 6-inch and at the center for the 8-inch shell. The compound plate was perforated by all the shells and practically destroyed by the 6-inch alone. The steel plate kept out all the shells, but was badly cracked by the 8-inch. The nickel plate kept out all the shells and remained without cracks."(a)

Congress was at once requested to appropriate (and did so) $1,000,000 for the purchase, at the discretion of the Navy department, of nickel ore. The report of the chief of the bureau of ordnance states that it may be confidently anticipated that nickel steel will enter into the composition of projectiles, both common and armor-piercing, of gun barrels for small arms, and later in the material used in the construction of artillery of large caliber.

This report has made a great impression and has resulted in active search for nickel ores, the strengthening of the producing concerns, and the establishment in this country of at least one concern for the manufacture of nickel steel.

a Official report of the bureau of ordnance.

ALUMINUM.

ALUMINUM.

BY R. L. PACKARD.

METALLURGICAL HISTORY.

Aluminum has been attracting an amount of attention during the last 2 or 3 years which is out of proportion to its actual (1890) importance as a metal and the position in the arts which it has hitherto occupied. This is accounted for by the comparatively recent appearance of the metal in commerce, the difficulty of extracting it, and the unfamiliar and elaborate metallurgical processes which have been invented in consequence. Some of these processes are reproductions on a large scale of experiments which are not ordinarily used even in chemical laboratories. A brief résumé of the history of these methods of extraction and their results will give a correct idea of the scope and merit of the industry.

In 1807 and 1808 Sir Humphrey Davy succeeded in obtaining the metals from the alkaline earths baryta, strontia, lime, and magnesia by electricity. His method was to place a paste of the respective earths on a strip of platinum connected with the positive pole of a powerful battery, put mercury in a small cavity in the paste, and connect it with the negative wire of the battery. Under the influence of the current the metallic oxide (the earth) was decomposed, an amalgam of the metal which it contained was formed, and the pure metal was obtained from this by distilling off the mercury. On applying this method to a paste made of alumina, Sir Humphrey Davy could not obtain the expected amalgam. He therefore varied the experiment in a way which is notable in view of certain recent methods, and which he described as follows:

The first experiment by which I obtained evidence of its composition was made in 1808 by fusing iron negatively electrified in contact with it. The earth was moist in this process, and a very high voltaic power was applied. The globule of metal obtained was whiter than pure iron, effervesced slowly in water, becoming covered with a white powder, and the solution in muriatic acid decomposed by an alkali afforded alumina and oxide of iron.

He continues:

By passing potassium in vapor through alumina heated to whiteness the greatest part of the potassium became converted into potassa, which formed a coherent mass with that part of the alumina not decompounded, and in this mass there were numerous gray particles having the metallic luster and which became white when heated in the air, and which slowly effervesced in water.—Works, 1840, volume IV, page 262.

Inconclusive as these experiments are as far as the separation of aluminum is concerned, they are interesting as the pioneers of the two lines of experiments, the electrical and chemical, each of which afterward led to the establishment of a commercial process.

The next step in advance was in the line of chemical experiment. Sir Humphrey Davy had failed to obtain aluminum from alumina, the oxide of the metal, by potassium vapor. Some 20 years later Wöhler, by substituting the chloride of aluminum for the oxide in this operation, succeeded in obtaining the metal, and was able to determine its physical properties.

In the account of his own works, published in 1827 (Poggendorf's Annalen, XI, page 147), Wöhler describes Oersted's experiments, made 3 years previously, and attributes to him the discovery of volatile aluminum chloride, which he prepared by the method, now well known in practice, of passing chlorine gas over a mixture of alumina and carbon heated to redness. By acting on the chloride so obtained with potassium amalgam Oersted stated that he had obtained an amalgam of aluminum, from which he had recovered the metal by distilling off the mercury. Wöhler repeated this experiment, but was unable to obtain aluminum, the metal remaining, after distilling off the mercury, being only potassium left over from the amalgam which had been used in the experiment. He did, however, succeed in reducing aluminum chloride by potassium itself, operating in porcelain crucibles. The aluminum was obtained in the form of a gray powder, and was not pure.

In 1845 Wöhler renewed his experiments (Poggendorf's Annalen, LXIV, 1845, pages 447–451), but in order to avoid the lively chemical reaction he varied the arrangement in such a way as to keep the aluminum chloride and potassium separate while the potassium was melted in the vapor of the chloride. This was accomplished in two ways: first, he introduced the chloride into a platinum tube, and then placed a platinum boat containing potassium in the tube near it. The tube was gradually heated to redness, when the chloride was volatilized and passed in vapor over the melted potassium, which decomposed the chloride and liberated the aluminum. He also placed the potassium in a small porcelain crucible, which was set in a larger one, and the space between was filled with the chloride. The whole was well covered and heated, when the reaction occurred. As before, the aluminum so obtained seemed to be in the form of a gray powder, but on closer inspection this powder was seen to be composed of tin-white metallic globules. Wöhler determined the specific gravity and other properties of these globules.

These laboratory experiments were resumed by H. Sainte-Claire Deville in France in 1854, who substituted sodium for potassium and operated on a larger scale than his predecessors. He placed aluminum chloride in considerable quantity in a glass tube, into which porcelain boats containing sodium were introduced, and the tube was then heated. The aluminum chloride was volatilized, and, coming in contact with the melted sodium, was decomposed thereby with a lively incandescence, forming chlorides of aluminum and sodium and setting free the aluminum, which was retained in the double chloride in a finely divided state. This mixture was then placed in boats made of retort carbon, which were highly heated in a porcelain tube, through which a current of dry hydrogen was passed. The double chloride was distilled off by this means, leaving the aluminum, which was afterward remelted and run into ingots. This was the method which Deville carried out on a large scale in 1855 in a furnace consisting of a retort for distilling the aluminum chloride, a chamber connected therewith containing iron nails to hold any ferric chloride which might distill over, and a third chamber beyond this containing trays of sodium. The inventor found much to improve in the details of the process, and by 1859 it had become modified so that the reduction was effected in a reverberatory furnace and fluor spar or cryolite was used as a flux. The double chloride of aluminum and sodium which was used in this operation was made by heating a mixture of alumina, carbon, and common salt in a retort and passing dry chlorine gas through it, on the principle introduced by Oersted, whereby the double chloride was distilled over and was caught in a receiver. Since that date many improvements have been made in the way of lessening the cost of the materials used in the process, especially in the manufacture of sodium by the Castner process in England, but the metallurgy remains substantially as it was when Deville established it. (Deville, de l'Aluminum, Paris, 1859.) This was the only process in practical operation in Europe down to 3 or 4 years ago. No serious attempt was ever made to introduce it into this country, because the limited uses and the high price of aluminum and its difficult metallurgy, which would be still more costly in this country than in Europe, where the refinements of chemical technology are more familiar than here, all conspired to repel investment in any large way.

The first step in advance in the electro-metallurgy of aluminum dates from the electrical decomposition of the fused double chloride of aluminum and sodium in 1854. The electrical decomposition of fused magnesium chloride by Professor Bunsen led to operating in a similar way on the fused double chloride of aluminum and sodium. Bunsen, in Germany, and Deville, in France, obtained metallic aluminum in this way, but no attempt was made to repeat the operation on an industrial scale until a much later date, when the introduction of modern dynamo-electric machines made it feasible.

The Siemens "electric furnace", patented in England in 1879, which was the forerunner of certain recent furnaces, may be regarded as a further advance toward the electro-metallurgy of aluminum. It consisted of a large crucible, connected with the poles from a dynamo and placed in a vessel filled with charcoal. The cathode passed through the bottom of the crucible, and was in contact with the metal to be melted by the heat of the current. The anode passed through a hole in the cover of the crucible, and the distance between the poles was ingeniously regulated by a solenoid. Iron, steel, and platinum were melted in this crucible. (English patent 2110 of 1879; Description of operation by dynamos, Ann. de chimie, sér. 5, tome 30, page 465.)

The intense heat which the electric current is capable of producing for metallurgical purposes was now known. It was also known that aluminum could be obtained by electrolysis, and the time was ripe for the industrial application of these facts as soon as dynamo electricity could be made available. Accordingly, in the last decade electro-metallurgical processes for obtaining aluminum have become favorite subjects for patents with inventors. It is sufficient to describe briefly the two which have been commercially successful in this country, and they will serve as types of all. The earlier of these, the Cowles process, was established in 1885, and is carried on by the Cowles Electric Smelting and Aluminum Company at Lockport, New York. It is at present (1890) confined to the production of aluminum alloys, viz, aluminum bronze (and brass) and ferro aluminum. This was the pioneer of such processes in the United States, and created an industry which has since been developed and extended. This process, which is now well known to persons interested in metallurgy, consists in passing the current from a powerful dynamo through a mixture of alumina (in the form of corundum, bauxite, etc.), carbon, and pieces of copper contained in a suitable vessel lined with carbon, through the ends of which vessel the large terminals of the dynamo are inserted. The mixture is arranged so as to prevent short circuiting. On passing the current the alumina is reduced in the presence of carbon and unites with the melted copper to form an alloy rich in aluminum. This alloy is afterward remelted, and enough copper added to it to reduce the aluminum contents to the proportions desired for aluminum alloys of the required grades.

The Cowles company has produced aluminum bronze as follows:

PRODUCT OF ALUMINUM BRONZE.

YEARS.	Pounds.	Value.
1885	4,000 to 5,000	$1,600 to $2,000
1886	50,000	20,000
1887	144,764	57,000

Besides aluminum bronze, the Cowles company makes ferro-aluminum by the same process by which the bronze is made, substituting iron for copper. The alloy, containing from 5 to 10 per cent of aluminum, is used as a vehicle for introducing aluminum into molten iron. An idea of the growing demand for ferro aluminum for this metallurgical use is obtained from the statement of the Cowles company that they made in 1886 from 2,000 to 3,000 pounds, valued at from $780 to $1,170, and in 1887, 42,617 pounds, valued at $16,621. The total aluminum alloys produced in 1889 amounted to 171,759 pounds.

Many proposals have been made and many patents obtained for making alloys of aluminum with iron and sometimes with copper by reducing alumina with carbon in the presence of fluxes and the metals. Clay, kaolin, and other compounds of alumina, it is asserted, may be used for this purpose. Sometimes the iron or copper is added to the melted mixture used as a "bath", sometimes the mixture is added as a flux to iron in a cupola or similar furnace, and sometimes it is used as a paste on iron, which is then heated. The object in most cases is to make an iron aluminum alloy for "beneficiating" iron. The announcement of the good effect produced on iron by adding minute quantities of aluminum to it while melted and Mr. Keep's experiments on this subject have probably led inventors to patent processes of the above kind. It is to be regretted that these processes do not yet offer clear and certain evidence that they are distinct and decided improvements like the electrical processes, or, indeed, that they are operative in the manner described.

The Herault process, which, like the Cowles, makes aluminum alloys, had not been put into commercial operation in this country up to the close of the census year.

In the United States the extraction of aluminum itself is also effected by dynamo electricity, and is a new industry carried on by the Pittsburg Reduction Company at Pittsburg, Pennsylvania, operating under the patents of Mr. C. M. Hall. The process consists in forming a fused bath of the fluorides of aluminum, calcium, and sodium, to which calcium chloride is subsequently added, by melting a mixture of cryolite, aluminum fluoride, and fluor spar in a suitable vessel lined with carbon, adding alumina thereto, and then separating the aluminum by the current from a dynamo, the carbon electrodes of which dip into the bath. The process is continuous, because the alumina is renewed as it becomes exhausted. One merit of the process is that the fused bath is of less specific gravity than the aluminum set free, which therefore sinks to the bottom of the vessel. If alloys are desired, the negative electrode is formed of the metal which it is desired to alloy with aluminum. Variations in the composition of the bath are described in the different patent specifications, but that above given is believed to be the one used in practice. This company produced 19,200 pounds of aluminum in 1889, which was sold at $2 per pound in quantity. The total production of aluminum in the United States during 1889, including that contained in alloys, was 47,468 pounds, with a total value of $97,335.

Until the recent metallurgical use of aluminum in treating molten iron was introduced the metal was worked in this country in a small way, principally for parts of optical, engineering, and astronomical instruments, balance beams, light weights, and the like, where lightness and strength are desired. An idea of the extent of its use may be had from the following table of imports, which shows the amount of aluminum entered for consumption in the United States:

ALUMINUM IMPORTED INTO THE UNITED STATES.

YEARS ENDED—	Quantity. (Pounds.)	Value.	YEARS ENDED—	Quantity. (Pounds.)	Value.
June 30, 1870	....	$98.00	June 30, 1880	340.75	$4,042.00
1871	....	341.00	1881	517.10	6,071.00
1872	....	....	1882	566.50	6,495.00
1873	a2.00	2.00	1883	426.25	5,079.00
1874	a783.00	2,125.00	1884	595.00	8,416.00
1875	a434.00	1,355.00	1885	439.00	4,736.00
1876	139.00	1,412.00	1886	452.10	5,369.00
1877	131.00	1,551.00	Dec. 31, 1887	1,260.00	12,119.00
1878	251.00	2,978.00	1888	1,348.53	14,086.00
1879	284.44	3,423.00	1889	998.83	6,688.07

a Probably alloys.

TOTAL PRODUCT OF ALUMINUM.

To conclude this review of the subject, it is a matter of curiosity to form an idea of the quantity of aluminum which has thus far been extracted. France was the only country which produced aluminum commercially until a few years ago. It had never been seen in any quantity until the Paris Exposition of 1855, where it was shown in ingots and in the form of manufactured articles of various kinds. Among ornamental articles it was noticed that a small body of the imperial guard wore breastplates of aluminum. The price of the metal was then 2,000 francs per kilogram. The production was as follows:

FRENCH PRODUCTION OF ALUMINUM IN 1863, 1867, AND 1872. (*a*)

	TONNES.
1863	1.0
1867	1.7
1872	1.8

a Paris Exposition, 1878, report of United States Commissioners, volume IV, page 184.

Aluminum was still somewhat of a curiosity in 1878, and was exhibited at the Paris Exposition in blocks, wire, sheets, and foil, and in the form of "objects, from a thimble and penholder to dinner sets of aluminum bronze and metal". (Ibid., page 84.) Telescopes, opera glasses, and other optical instruments, mounted wholly or in part in aluminum, and chemical balances made of the same metal, were shown, which were very light and strong.

Later statistics give the aluminum product for France as follows:

LATER ALUMINUM PRODUCT OF FRANCE.

YEARS.	Amount. (Kilograms.)	Value. (Francs.)
1886	2,430	243,000
1887	2,040	204,200
1888	2,955	295,500

These figures are taken from the official report published by the ministère des travaux publics, "Statistique de l'industrie minérale, etc., 1886–1888."

Allowing the French production to have been 1.5 tonnes a year from 1860 to 1880 and 2.5 tonnes from that date to 1889, inclusive, we should have 31.5+22.5=54 tonnes, or about 60 short tons, in the 30 years.

The Journal of the Society of Chemical Industry, July 31, 1890, page 781, gives the English production of aluminum as follows:

ENGLISH PRODUCTION OF ALUMINUM.

YEARS.	Amount. (Pounds.)	Value at average market price in London.
1888	5,000	£5,000
1889	12,000	6,000

There was an English manufacture of aluminum from about 1860 to 1874, but no statistics of its production are obtainable. It could not have been very considerable, as the price of the metal was then very high. The Castner process was inaugurated in England in 1888. Supposing 5,000 pounds per annum to represent the English production from 1883, when the Webster process was put in operation, to 1888, we have 30,000 pounds, which, with the 12,000 pounds for 1889, equaling 42,000 pounds, or 21 tons, may be regarded as the English production up to the beginning of 1890. The French and English production together would therefore amount to about 82 tons. The Aluminum und Magnesium Fabrik, at Hemelingen, near Bremen, has been in operation since the latter part of 1887, and has supplied all the aluminum produced in Germany. The production of this company is given as follows:

PRODUCTION OF ALUMINUM BY THE ALUMINUM UND MAGNESIUM FABRIK.

	KILOGRAMS.
1887	1,700
1888	8,400
1889	9,500
Total	19,600

Adding this total to the figures representing the sum of the French, English, and the American production from all sources, exclusive of alloys, which is nearly 94 short tons, we get, in round numbers, 116 short tons, which therefore represents the total production of aluminum from 1860 to 1889, inclusive. This is an inconsiderable quantity of metal, but the indications are that the manufacture will be so largely increased from now on that this amount will soon be exceeded by the annual production.

PHYSICAL PROPERTIES.

The tenacity of commercial aluminum is given by Mr. W. J. Keep as 18,866 pounds per square inch for a specimen, the probable composition of which was aluminum, 96.96 per cent; silicon, 0.59 per cent, and iron, 1.79 per cent. This was an average of 4 tests which were made by Mr. Theodore Stevens. The specific gravity of the metal was 2.66. Another series of tests of commercial aluminum containing 95.50 per cent aluminum, 1.62 per cent silicon, and 2.88 per cent iron gave 17,425 pounds per square inch tensile strength, the specific gravity being 2.72. (Transactions of the American Institute of Mining Engineers, Washington meeting, February, 1890.) On the other hand, tests made by Mr. W. H. Barlow give 26,800 pounds per square inch as the tensile strength, and tests of aluminum made by the Deville-Castner process give from 25,000 to 30,000 pounds. (Richards' Aluminum, 1890, pages 65, 66.)

The following table, taken from Professor Thurston's text-book on the Materials of Construction, gives the specific gravities and weights of 1 cubic foot of aluminum and several other commercial metals and alloys:

SPECIFIC GRAVITIES AND WEIGHTS OF ALUMINUM, ETC.

SUBSTANCES.	Specific gravity.	Weight of 1 cubic foot. (Pounds.)
Aluminum, cast	2.560	160
Aluminum, sheet	2.670	167
Bronze (ordinary)	8.400	524
Copper, bolts	8.850	584
Copper, cast	8.600	537
Copper, sheet	8.880	549
Copper, wire	8.880	550
Iron, cast	from 6.955 to 7.295	435 to 456
Iron, cast, average	7.125	445
Iron, wrought, average	7.680	480
Steel, hard	7.820	496

The tensile strength and other properties of the Cowles aluminum bronze and brass are shown in the following table, taken from the official report of tests made under the direction of the engineer in chief of the navy at Watertown, Massachusetts:

TESTS MADE ON SPECIMENS OF ALUMINUM BRONZE AND BRASS.

Mark or number.	APPROXIMATE COMPOSITION.	Length between reference marks. (Inches.)	Diameter. (Inches.)	Area. (Square inches.)	Tensile strength per square inch. (Pounds.)	Elastic limit per square inch. (Pounds.)	Elongation in 15 inches. (Per cent.)	Reduction of area. (Per cent.)	Diameter at fracture. (Inches.)	HARDNESS.	
										Head.	Stem.
1 C	Cu 91.5, Al 7.75, Si 0.75	15	1.875	2.7612	60,700	18,000	23.20	30.70	*a*1.56	9.39	13.85
7 C	Cu 88.66, Al 10, Si 1.33	15	1.875	2.7612	66,000	27,000	3.80	7.80	*a*1.80	14.12	14.26
9 C	Cu 91.5, Al 7.75, Si 0.75	15	1.875	2.7612	67,600	24,000	13.00	21.62	*a*1.66	11.18	13.59
10 C	Cu 90, Al 9, Si 1	15	1.875	2.7612	72.830	33.000	2.40	5.78	*a*1.82	....	....
11 C	Cu 63, Zn 33.33, Al 3⅓, Si 0.33	15	1.875	2.7612	82,200	60-73,000	2.53	9.88	*a*1.78	14.69	10.60
13 C	Cu 92, Al 7.5, Si 0.5	15	1.875	2.7612	59,100	19,000	15.10	3.59	*a*1.64	....	....
9 D	Cu 91.5, Al 7.75, Si 0.75	15	1.900	2.8400	53.000	19,000	6.20	15.50	*b*1.75	....	....
10 D	Cu 90, Al 9, Si 1	15	1.890	2.8100	69.930	33,000	1.33	3.30	*b*1.86	....	....
11 D	Cu 63, Zn 33.33, Al 3.33, Si 0.33	15	1.900	2.8400	70,400	55,000	0.40	4.33	*b*1.86	....	....
13 D	Cu 92, Al 7.5, Si 0.5	15	1.930	2.9300	46,550	17,000	7.80	19.19	*b*1.73	....	....

a Chill castings. *b* Dry sand castings.

Aluminum bronze is used for all purposes where strength and durability are required, and is furnished in all forms, such as large and small castings, ingots, billets, slabs, rods, sheets, bars, and wire. The propeller wheel for gunboat No. 2 of the United States navy was cast of this bronze.

For comparison, the following figures, showing the tensile strength of other bronzes and brasses and some kinds of iron and steel, are also taken from Thurston's text-book, referred to above. The strength of brasses varies greatly, the specimens tested being of different composition. The highest tensile strength given in the table from which these figures are taken is 52,928 pounds per square inch (composition, copper 79.65 per cent, zinc 20.35 per cent), and the lowest 1,568 pounds per square inch (composition, copper 29.17 per cent, zinc 70.83 per cent). Copper itself is given at 55,104 pounds. Bronzes range from 42,692 pounds per square inch (composition, copper 96.27 per cent, tin 3.73 per cent) down to 1,455 pounds per square inch (composition, copper 56.70 per cent, tin 43.17 per cent). Steel containing 0.53 per cent of carbon, other constituents not given, had a tensile strength of 79,062 pounds per square inch, while another specimen with 1.09 per cent carbon had a tensile strength of 116,394 pounds. The tensile strength of cast iron is given as follows:

	POUNDS.
Good cast-iron pig, up to	20,000
Tough cast iron, up to	25,000
Hard cast iron, up to	30,000

A comparison with the above figures will also give an idea of the place aluminum itself occupies in respect to tensile strength.

SOURCES.

The principal sources of aluminum have hitherto been cryolite from Greenland and imported bauxite. The Greenland mine is at Evigtok, near Arksut. Previous to 1860 only small quantities of this cryolite were exported, but soon after that date the deposit was systematically worked, and cryolite was exported in considerable quantities. In recent years an American company, the Pennsylvania Salt Manufacturing Company, has imported several thousand tons annually. A writer in a New York journal describes the present appearance (1890) of the mine or quarry as "a hole in the ground, elliptical in shape, and, say, 450 feet long by 150 wide". The pit is 100 feet deep, and drills have penetrated 140 feet deeper and found cryolite all the way. This prospecting promises well for the future. The mine is close to the water's edge in Arksut fjord, and the ships of the American company's fleet visit the place every season and load directly from the "stock pile" of the mine.

The increased demand for alumina-bearing materials has called attention to American deposits of bauxite and "alum beds". Bauxite has been found in several places in Floyd county, Georgia. A notice of the mineral as far as known in 1887, at which time the deposit had not been opened to any extent, was published by Mr. Edward Nichols in the Transactions of the American Institute of Mining Engineers, volume XVI (1888), page 905. The analyses were as follows:

ANALYSES OF BAUXITE FROM FLOYD COUNTY, GEORGIA.

COMPONENT PARTS.	No. 1. (Per cent.)	No. 2. (Per cent.)	No. 3. (Per cent.)
Silica	2.80	....	2.300
Alumina	52.21	57.25	56.880
Iron oxide (Fe_2O_3)	13.50	3.21	1.490
Titanic acid (TiO_2)	3.52	3.60	3.550
Water	27.72	....	....
Phosphoric acid (P_2O_5)	....	....	0.066

No. 1 was a dark-colored specimen; Nos. 2 and 3, light-colored specimens.

The most recent discoveries of bauxite are in Saline and Pulaski counties, Arkansas. Dr. J. C. Branner, the state geologist, has made a report on the subject to the governor of that state, from which the following information is condensed.

The mineral or ore occurs in Arkansas only in tertiary areas and in the neighborhood of granites. It appears in irregular deposits, whose thickness and extent are determinable only by direct methods of examination. The Arkansas bauxite beds are known to cover a total area of about 640 acres in Saline and Pulaski counties. A sample from the Little Rock region analyzed as follows:

ANALYSES OF BAUXITE FROM PULASKI COUNTY, ARKANSAS.

COMPONENT PARTS.	No. 1. (Per cent.)	No. 2. (Per cent.)
Silica	10.13	11.48
Alumina	55.59	57.62
Iron (ferric) oxide	6.08	1.83
Water	28.99	28.63
Total	100.79	99.56

ANALYSES OF BAUXITE FROM SALINE COUNTY, ARKANSAS.

COMPONENT PARTS.	Black variety. (Per cent.)	Red variety, No. 1. (Per cent.)	Red variety, No. 2. (Per cent.)
Silica	5.11	4.89	3.34
Alumina	55.89	46.44	58.60
Iron (ferric) oxide	19.45	22.15	9.11
Water	17.39	26.68	28.63
Total	97.84	100.16	99.68

Many localities are mentioned where the deposits crop out in the area specified.

Besides bauxite, kaolin is mentioned in this report as occurring in Pike, Pulaski, Saline, and Ouachita counties. The composition of the Pike county kaolin is as follows:

ANALYSIS OF KAOLIN FROM PIKE COUNTY, ARKANSAS.

	PER CENT.
Silica	48.87
Alumina	36.54
Iron (ferric) oxide	0.98
Lime	0.19
Magnesia	0.25
Water	13.29
Total	100.12

That from Pulaski county is described as either modified bauxite or decayed granite, as follows:

ANALYSIS OF KAOLIN FROM PULASKI COUNTY, ARKANSAS.

	PER CENT.
Silica	46.27
Alumina	38.57
Iron (ferric) oxide	1.36
Lime	0.34
Magnesia	0.25
Potash	0.23
Soda	0.37
Water	13.61
Total	101.00

The Ouachita kaolin resembles a sandy clay, and its true nature would hardly be suspected from its general appearance. If the sand is washed out and the material analyzed it is found to have the same composition as some of the best kaolins. In the following table is an analysis of Ouachita county kaolin after removing the greater part of the sand. An analysis of a Pennsylvania kaolin from Brandywine Summit is given for comparison.

COMPARATIVE ANALYSES OF KAOLIN FROM ARKANSAS AND PENNSYLVANIA.

COMPONENT PARTS.	Ouachita county. (Per cent.)	Pennsylvania. (Per cent.)
Silica	48.62	47.24
Alumina	36.52	37.27
Iron (ferric) oxide	1.74	1.94
Water	13.40	13.62
Total	100.28	100.07

"Alum beds" have been found in Purgatory valley, about 12 miles east of Trinidad, Colorado, and some assessment work has been done there in locating claims and opening up the deposits. 2 deposits of a similar material have also been found on the Gila river, in New Mexico, 1 of which is some 20 miles from Silver City. It is said to be extensive, and many claims have been taken up and some prospecting work done. The other deposit is on the southern Gila, and fluor spar has been found in the neighborhood. Professor Huntington, of Silver City, from whom this information was obtained, forwarded a specimen from the deposit near Silver City, and an analysis shows the following results:

	Per cent.	
Alumina (Al_2O_3)	12.75	
Sulphuric acid (SO_3)	30.79	
Lime (CaO)	0.32	
Magnesia (MgO)	0.79	
Water (H_2O)	41.35	
Total soluble in water		86.00
Silica (SiO_2)	7.97	
Alumina and a little oxide of iron ($Al_2O_3+Fe_2O_3$)	5.22	
Lime (CaO)	0.27	
Undetermined	0.26	
Total insoluble in water		13.72
		99.72

The alumina is present as a sulphate, which easily dissolves in water.

On calculating the alumina, the sulphuric acid corresponding to it, and water to 100 per cent, neglecting the lime and magnesia, the result is as follows:

	Per cent.
Alumina (Al_2O_3)	15.16
Sulphuric acid (SO_3)	35.67
Water (H_2O)	49.17
Total	100.00

which is the composition of alunogen.